THE GLASS INDUSTRY

VOLUME 33, NUMBER 9, SEPTEMBER, 1952

MEASUREMENT OF SURFACE TENSION OF GLASSES

By DAVID W. MITCHELLL, STEPHAN P. MITOFF, VICTOR F. ZACKAY and JOSEPH A. PASK

University of California, Berkeley, California

PART I

Preface

The use of glass-metal, or more generally ceramic-metal, components has become commonplace and practically indispensable in industrial practice and in technical and scientific research. Such seals have vital application in electronics, ceramic protective coatings on metals, metallizing of glass surfaces, as well as in other allied fields. Then, in contrast, there are operations where adhesion of glasses to metal are undesirable. A fair amount of work on the physical aspects of the problem have been done, but there has been limited experimental inquiry into the fundamental chemical nature of the bonds between metal and glass.

This report is a critical review of the existing state of knowledge and data on surface tension of glasses, as well as an analysis of the forces existing in a sessile drop. The latter procedure, or measurement of wettability of metals by glasses, is the method being used by the authors to gather preliminary experimental data. The work to date has covered wetting studies of Ni, Pd, Pt, Cu, Ag and Au by several sodium silicate glasses in helium, hydrogen, oxygen and air, which was presented at the annual convention of the American Ceramic Society in April, 1952. It is being extended to other metals and glasses with the purpose of formulation of a theory of wetting which is necessary to an understanding of the fundamentals of glass to metal bonding. Reports of this work will be appearing as a series of papers.

Introduction

Short range attractive forces acting between two masses of matter brought into atomic or molecular contact with each other are described as adhesive or cohesive forces depending upon the nature of the two masses. When the two masses are unlike phases, the attractive forces are known as adhesive; and when the two masses are identical in composition and structure, the forces are known as cohesive. The extent of attraction of the two masses for each other is known as adhesion or cohesion. In the first case there remains an interface between the two unlike phases and it is the nature of this interface that determines largely the extent to which adhesion exists.

From what has been said above it is clear that the forces that cause adhesion are the same forces that are responsible for the stability or lack of stability of atomic or molecular aggregations. These forces are in evidence as electrostatic bonds in ionic crystals, as covalent bonds such as hold hydrogen or chlorine gas atoms together to form hydrogen or chlorine molecules, as metallic bonds like those holding metal atoms together in metals and alloys, and as the van der Waals forces which hold the molecules of molecular crystals together. The nature of these types of chemical bonds is discussed in many advanced works on physical chemistry and physics. A concise description of the types of bonds important in adhesion has been published by Kline and Reinhart.[1]

An atom or atomic group (the basic building unit of the substance) within the body of a homogeneous mass of matter is acted upon by the cohesive forces that hold the body together and possesses a certain potential energy. When the same atom or atomic group is moved to the surface from within the body its potential energy is increased by the amount of work required to change its position. It experiences a net attractive force acting in the direction of the interior of the body for it has no neighbors on the side away from the body of material. When this increase in potential energy is expressed, not as energy units per atom or atomic group but as energy units per unit of surface area, this quantity is known as the specific surface energy. Thus it is seen that surface energy is a difference quantity—the difference in potential energy between the material in bulk and the same material in the surface.

Since the net force acting on surface units is toward

This report is a preliminary study in connection with research on the "Mechanics of Metal-Ceramic Bonding" sponsored by the Atomic Energy Commission in the Division of Mineral Technology at the University of California at Berkeley.

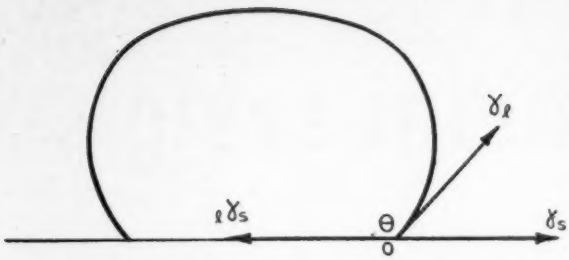


Fig. 1. The sessile drop. $\gamma\lambda$, γ_s, and $\lambda\gamma_s$ represent the surface energies of the liquid, the solid and the liquid-solid interface, respectively. Note that Θ is measured through the liquid phase.

the interior of the mass of material, the surface area is minimized if the material is fluid enough to permit deformation by this force. If the substance is liquid, such a behavior is familiar and is customarily ascribed to a phenomenon known as surface tension. As treated in many elementary texts, surface tension is considered to be a force exerted by the surface layer in all directions tangent to the surface. This concept is perfectly satisfactory if one keeps in mind that the surface layer is not and does not behave as an *elastic* membrane and that the existence of such a force is a mathematical convenience created for purposes of simplicity in considering problems involving surface tension. Increasing the surface area of a body of liquid entails the movement of atomic units from the interior of the liquid to its surface. If the tension is represented by a tangential force, then the work done in creating new surface is equal to the product of this force and the distance through which it acts. If only unit width of surface is considered, the work done in increasing the surface area will be numerically equal to the product of the surface tension force and the distance. In general the work can be considered the product of the surface tension force per unit of length in the direction perpendicular to the direction through which it acts and the surface area produced by its action. Thus the numerical value of surface tension expressed as force per unit length is equal to the value of the specific surface energy in energy units per unit of surface area. Because of this numerical equivalence surface tension and specific surface energy are used almost interchangeably in mathematical treatment of surface phenomena.

When a drop of liquid is placed upon a smooth solid surface, the liquid spreads over the solid to an extent that depends upon the chemical nature of the substances concerned. All degrees of spreading are possible for different pairs of substances. The extent of spreading may be described by giving the magnitude of the angle of contact between the solid surface and the tangent to the liquid surface at the point of contact, the angle usually being understood to be measured through the liquid phase. In Fig. 1, Θ is the contact angle.

Fig. 1 shows the surface forces acting at a point of liquid-solid contact. For purposes of simplicity, in the present discussion there is considered to be no vapor above the condensed phases and the vapor pressures of the substances concerned to be negligible. Further, the surfaces of the solid and liquid are both considered to be uncontaminated. The surface tension of the liquid, taken as equal to its specific surface energy, acts at 0 in the direction tending to minimize the liquid surface and is represented by γ_λ. The surface tension of the solid tending to minimize the solid surface is shown by γ_s, and similarly the interfacial tension tending to minimize the interface between the two phases is shown as $\lambda\gamma_s$. $\lambda\gamma_s$ is numerically equal to the specific interfacial energy. Under equilibrium conditions (or perhaps it is better to say conditions under which the contact angle does not change because the condition of perfect vacuum assumed cannot be attained) equating the horizontal components of the forces gives Young's equation:

$$\gamma_s = {}_\lambda\gamma_s + \gamma_\lambda \cos \Theta \qquad (1)$$

In using Young's equation without modification, it must be kept in mind that the surface tensions and their numerically equivalent quantities, specific surface energies, are those obtained assuming a perfect vacuum. In sensible atmospheres the surface energies may be modified by adsorption of, or reaction with, the constituents of the atmosphere leading to energy values that may be very different from the energies of the clear surfaces.

Of the quantities appearing in equation (1) we ordinarily have experimental data for γ_λ only. Values of γ_s are practically impossible to determine by experiment but values for ionic crystals may be calculated by the methods of crystal chemistry.[2] For metals, theoretical calculations of values for γ_s cannot be made with a high degree of reliability, so that for purposes of glass to metal adhesion studies γ_s is an unknown quantity. Values of $\lambda\gamma_s$ are likewise not available experimentally or capable of theoretical calculation although interfacial energies for many liquid-gas and liquid-liquid systems are readily determined by experiment. It should be noted here that most surface tension values reported in the literature are actually interfacial tensions between liquids and inert (toward the particular liquid) gases. In such cases the surface tension of the liquid is little different from that in vacuum (or in equilibrium with its own vapor only).

Equation (1) may be modified to eliminate the unknown quantities γ_s and $\lambda\gamma_s$ in order to obtain several commonly used measures to adhesion. One such measure is the work of adhesion, W_{Ad}, which is the minimum energy necessary to destroy unit interface between the liquid and solid when equilibrium exists and to replace it with unit areas of solid surface and of liquid surface or, put in another way, W_{Ad} is the minimum energy required to pull the liquid off the solid leaving clean solid and liquid surfaces. This is expressed by the Dupre equation:

$$W_{Ad} = \gamma_\lambda + \gamma_s - {}_\lambda\gamma_s \qquad (2)$$

Substituting for $\gamma_s - {}_\lambda\gamma_s$ in equation (2) its equivalent from equation (1),

$$W_{Ad} = \gamma_\lambda (1 + \cos \Theta) \qquad (3)$$

Strong adhesion between *a liquid and a solid* is obtained when the work of adhesion is large. When $W_{Ad} > \gamma_\lambda$ or $\Theta < 90°$, the adhesive forces between the solid and liquid are greater than the cohesive forces acting within the liquid and it is therefore impossible to pull the liquid off the solid surface—any break will occur in the liquid. When $W_{Ad} = \gamma_\lambda$ or $\Theta = 90°$, the system is indifferent as to whether the liquid adheres better to the solid or to itself. When $W_{Ad} < \gamma_\lambda$ or $\Theta > 90°$, the liquid may be completely removed from the solid surface—the cohesive forces within the liquid are stronger than the adhesive forces between the two phases.

A somewhat similar measure of adhesion is adhesion

tension, γ_{Ad}, which is defined by

$$\gamma_{Ad} = W_{Ad} - \gamma_\lambda = \gamma_\lambda (1 + \cos \Theta) - \gamma_\lambda \quad (4)$$
$$= \gamma_\lambda \cos \Theta$$

The adhesion tension varies from γ_λ to $-\gamma_\lambda$ as the contact angle varies from 0 to 180° corresponding to complete spreading and complete non-spreading of the liquid on the solid surface.

In order to define another measure of adhesion, it is first necessary to define work of cohesion. The quantity, W_{Co}, is the minimum energy required to pull apart a column of liquid of unit cross section at a plane surface perpendicular to the direction of pull. Hence W_{Co} is twice the specific surface energy of the liquid, $W_{Co} = 2\gamma_\lambda$.

The difference of the work of cohesion for the liquid to the work of adhesion for the two phase system results in a quantity known as the spreading coefficient (or, more precisely, the initial spreading coefficient) $W_{Ad} - W_{Co}$. The spreading coefficient may be expressed as in equation 5.

$$W_{Ad} - W_{Co} = \gamma_\lambda (1 + \cos \Theta) - 2\gamma_\lambda \quad (5)$$
$$= \gamma_\lambda (\cos \Theta - 1)$$

This coefficient varies from zero for a contact angle of 0° to $-2\gamma_\lambda$ for a contact angle of 180°.

To effectively form a glass-metal seal it is necessary for the glass to spread on the metal at the sealing temperature; that is, the coefficient of spreading must be large. The rate of approach to the equilibrium contact angle is dependent upon the viscosity of the liquid. Thus, the viscosity enters only as a time factor.

Methods of Measurement

In the following section the experimental methods for the determination of surface tension of molten glasses are surveyed. Equations and the general theory of each method are given.

(1) Drop Weight

Tate[3] stated as a "law" that the weight of a drop which falls from a tube (or molten drop from a rod) depends on the radius of the tube (or rod), and the surface tension of the liquid, in the following manner

$$W = 2\Pi r \gamma \quad (6)$$

where:

W = weight of drop.
r = radius of tube (or rod).
γ = surface tension.

Quincke[4,5] applied this formula to a large number of easily fusable salts. Lord Rayleigh[6] later pointed out that: 1) the weight of a drop increases relatively faster than the diameter of the tube for small drops, and 2) remains constant if the diameter of the tube is increased beyond a certain size.

Quincke[4,5] developed a relation which tends to correct these effects:

$$W = ad + bd^2 \quad (7)$$

where:

W = weight of drop.
d = diameter of rod.
a = a number depending on surface tension.
b = a constant depending on "cohesion" of liquid, approximately equal to 15 in cgs units, for molten glass.

Tillotson[7] found general agreement with this relation, applying it to thin glass fibers heated in an open flame. He was cognizant of the fact, however, that the equation could not meet both the conditions implied by Lord Rayleigh. His values of surface tension appear to be too low.

A modification of this method was used by Lecrenier[8] who used the drop weight of glass sample obtained by melting the glass in a crucible with a circular orifice at the bottom, the surface tension being calculated by the formula of Guglielmo[9].

$$\gamma = \frac{W}{2\Pi r}(1 + r/R) \quad (8)$$

where:

R = radius of curvature at widest point of globule.
r = orifice radius (1.928 mm).

Lecrenier obtained results which were apparently too high. This would seem to indicate, when compared with the similar method of Tillotson, that the accuracy of the drop weight method in general is uncertain. As stated by Tillotson, however, the method is useful for comparison of relative surface tensions of glass samples, due to the simple apparatus and speed of measurement.

(2) Elongated Fiber

Tammann and Rabe[10] and Tammann and Tapke[11] proposed to determine surface tension by shrinkage and elongation of glass fibers. Application of heat to a vertical fiber, supported only at the top, causes the following changes to take place in this order:

(1) Length increases, due to thermal expansion.
(2) Length decreases, due to action of surface tension.
(3) Length increases as gravity overcomes surface tension.

The enlargement in diameter is maximum just before the second lengthening begins. By equating the force of surface tension to that of gravity, the former quantity may be determined.

$$2\gamma = W/2\Pi r \quad (9)$$

where:

γ = surface tension.
W = weight of fiber from heated portion to lower end.
r = radius of fiber.

Keppeler[12] used a similar method which consisted essentially of finding a point at a distance from the end which would neither shrink nor elongate when heated.

In general the above methods appear to yield low results and experimental conditions do not permit great accuracy but, again, the procedure is convenient and simple.

(3) Pendant Drop

Recently a method has been presented by Davis and Bartell[13] which is claimed to yield precise and reproducible results. When a glass rod is heated at the bottom end a bulb will form. The drop is allowed to cool and measurements are taken as illustrated in Fig. 2. Surface tension may then be calculated from formula 10.

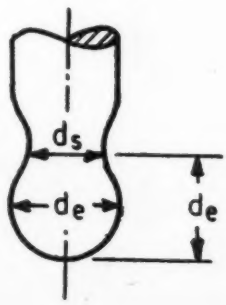


Fig. 2. The pendant drop, as shown by Davis and Bartell. The diameter at the selected plane, d_s, is taken at a distance, d_e equal to the maximum drop diameter, from the base.

$$\gamma = \rho g d_e^2 \, (1/H) \qquad (10)$$

where:

ρ = difference in density of glass and medium surrounding it.
g = gravitational constant.
d_e = maximum diameter of drop.
$1/H$ = a function of the ratio of diameter at the selected plane to equatorial diameter, d_s/d_e. An empirical evaluation of this function is given by Andreas, Hauser and Tucker[14].

In order to work at room temperature the following conditions must be employed, where d_e, d_s and ρ signify high temperature values and d_e', d_s' and ρ' room temperature.

For an anisotropic substance

$$(d_e/d_e')^3 = v/v' = \rho'/\rho$$

Therefore

$$d_e^2 = d_e'^2 \, (\rho'/\rho)^{2/3} \qquad (11)$$

Substitution into equation (10) results in

$$\gamma = \rho'^{2/3} \, \rho^{1/3} \, g d_e'^2 \, (1/H) \qquad (12)$$

The results were calculated by the authors using the equation in the above form, although the error involved in assuming that the density of the cold glass could be used, that is that

$$\gamma = \rho' g d_e'^2 \, (1/H) \qquad (13)$$

is a factor of only $(\rho'/\rho)^{1/3} - 1$.

The results therefore depend on the assumption that the shape of the drop does not change, and hence 1/H is constant. The values given were in good agreement with other recent figures for similar glasses.

(4) Dipping Cylinder

The surface tensions for glasses in a region of the soda-lime-silica system were measured by Washburn, Shelton and Libman[15]. Their method consisted of dipping a hollow platinum cylinder into molten glass and obtaining surface tension by the elongation of the spring of a Jolly balance. The surface tension may be calculated from the following formula:

$$\gamma = KgE/2L = (h\rho gw/2) \, (1/\cos \Theta) \qquad (14)$$

where:

L = circumference of cylinder.
K = spring constant (Hooke's law).
E = spring elongation.
h = depth of submergence into glass.
w = thickness of cylinder.
Θ = contact angle.

Density was accounted for by taking readings at different heights and eliminating ρ with two simultaneous equations. The assumption was made that the contact angle of the glass with the platinum was zero.

Their results were lower (by as much as one half) than those obtained later by similar methods which did not rely on the assumption of zero contact angle as well as those obtained by the maximum bubble pressure method. This discrepancy will be discussed later.

Backcock[16] used a somewhat similar apparatus and formula, i.e.:

$$\gamma = KgE/2L \qquad (15)$$

However, he determined the maximum pull on the cylinder so that the liquid would be in contact with only the bottom surface of the ring, at the instant of the reading, thereby eliminating contact with the side of the cylinder, and the necessity of considering Cos Θ. His results were in agreement with those obtained by the maximum bubble pressure method, and much larger in magnitude than the results of Washburn and Shelton. Ellefson and Taylor[17] have shown a sodium silicate glass to have a contact angle on platinum of about sixty degrees in vacuum and nitrogen atmosphere but zero in oxygen. They offer this as a possible explanation for the low values recorded by Washburn et al. if the partial pressure of the oxygen were somehow reduced.

Harrison and Moore[18], using a similar apparatus but with a torsional spring, also drew the cylinder above the liquid surface "to insure zero contact angle," but their method was static; that is, it was not a continuously withdrawn cylinder. The same formula was used as in the previous methods, modified to suit the torsional wire.

The most recent work in the measurement of surface tension of glasses is that of Shartsis and Smock[19], Shartsis, Spinner and Smock[20], Shartsis and Canga[21] and Shartsis and Spinner[22]. Their method is that of the maximum pull on a platinum cylinder. The equation used was one developed by Verschaffelt:

$$T = (F/4\Pi R)\,[1 - \{2.8284 + 0.6095\,(h/R)^{1/2}\}(\delta/h^{1/2}R^{1/2}) + \{3 + 2.585\,(h/R)\}^{1/2}\,\delta^2/hR] \qquad (16)$$

where:

F = excess force due to surface tension.
R = mean radius of cylinder.
2δ = thickness of cylinder wall.
$h = F/\Pi R^2 \rho g$.
ρ = density of liquid.

This formula corrects for the finite thickness of the platinum cylinder. In order to facilitate computation a graph of the Verschaffelt correction (between 0.91 and 0.96) was plotted against ρ/W_{max} where W_{max} is the maximum pull on the cylinder, and the surface tension was then computed from $FV/4\Pi R$, where V is the correction.

Results of this work are in good agreement with maximum bubble pressure values of Badger, Parmelee and Williams[23].

(5) Maximum Bubble Pressure

F. M. Jaeger[24] developed a method for the measurements of surface tension of melts which relies on the principle that a bubble at the end of a tube submerged in a liquid will exert the maximum back pressure when it is hemispherical in shape.

At first it was feared that glass melts would be too viscous for application of this method, but Parmelee and Harman[25], Badger, Parmelee and Williams[23], and Keppeler[12] have obtained reliable results using bubble pressures.

At the maximum pressure, P_{max}, the following equation may be applied.

$$P_{max} = P_1 + P_2 = gh\,(\rho_1 - \rho_2) + 2\gamma/r \qquad (17)$$

where:

P_1 = hydrostatic pressure.
P_2 = pressure due to curvature of the surface.
h = depth of submergence.
ρ_1 = density of glass.
ρ_2 = density of gas.
r = radius of tube.

However, for large drops a correction must be applied for the hydrostatic flattening of the bubble, as given by Dorsey[26].

$$\gamma = (P_2 r/2)\,(1 + 2r/3h + 1/6(r/h)^2 + \ldots.) \qquad (18)$$

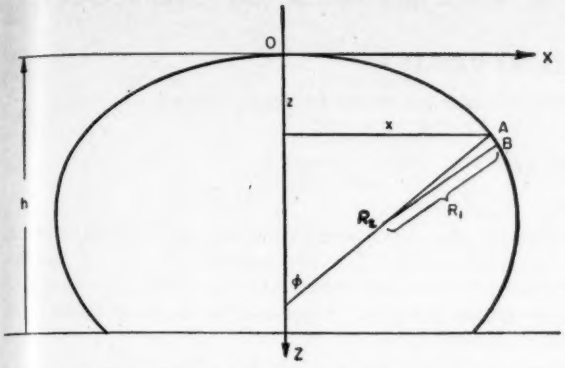


Fig. 3. The sessile drop, with symbols as required for the tables of Bashforth and Adams. The height, h, is taken as being positive in the upward direction for the purposes of Quincke's approximation formula only.

Parmelee and Harman found it necessary to use only the first two terms of the series.

(6) Bulb Method

Pietenpol[27] devised a method to measure surface tension of glass, which consists essentially of four steps: (1) A bubble 3.5 to 5 cm. in diameter is blown at the end of a glass tube; (2) The bubble is placed in a furnace with a plaster support; (3) Heat is applied to the furnace and pressure to the bulb; (4) Temperature and diameter are recorded when the molten state is reached. The surface tension may be determined by equating the excess pressure effect to the pressure of surface tension.

$$2\,\Pi\,B\gamma = \Pi\,B^2P/4 \qquad (19)$$

where:

B = diameter of bulb.

P = gas pressure.

A correction is made for the weight of the suspended portion of the bulb.

When the bulb is increasing or decreasing in size, the readings are viscosity dependent, yielding high values of surface tension when increasing and low when decreasing.

(7) Sessile Drop

If a drop of molten glass is allowed to rest, at equilibrium, on a surface which it does not completely wet, the shape of the drop is dictated by gravity, the interfacial tension of the solid and liquid, and the surface tension of the drop (neglecting the vapor phase). The differential equation representing the shape of the drop has never been rigorously solved, but a number of approximation formulae and numerical tables have been presented.

The sessile drop may take on a shape similar to that illustrated in Fig. 3. The excess pressure, P_2, is described by the relation:

$$P_2 = \gamma(1/R_1 + 1/R_2) \qquad (20)$$

where:

R_1 = radius of curvature of an infinitesimal segment, AB, of the drop in the plane of the Z axis (vertical).

R_2 = radius of curvature normal to A, rotated about Z axis and equal to $x/\sin\phi$.

Note that the two principal radii are always perpendicular and are identical at the origin.

The hydrostatic pressure P_1 will be:

$$P_1 = g(\rho_1 - \rho_2)\,z = g\rho z \qquad (21)$$

where:

ρ_1 = density of liquid.

ρ_2 = density of surrounding medium.

$\rho = \rho_1 - \rho_2$.

z = distance below apex of drop.

Equating (15) and (16), $P_2 = P_1 +$ constant

$$\gamma(1/R + \sin\phi/x) = g\rho z + \text{contant} \qquad (22)$$

The constant results from the integration over small elements of incompressible volume for which (22) applies:

Now when $z = O$, $R_1 = R_2$, then call the radius of curvature at the apex b.

Then:

Constant $= 2\gamma/b$

The equation becomes:

$$\gamma(1/R_1 + \sin\phi/x) = g\rho z + 2\gamma/b \qquad (23)$$

In order to get R_1 in terms of x and z, the differential expression for a radius of curvature may be substituted for R_1:

$$R_1 = \frac{[1 + (dz/dx)^2]^{3/2}}{(d^2z/dx^2)} \qquad (24)$$

However, the resulting second order differential equation has not been integrated by rigorous methods, so that the accuracy with which surface tension may be measured from a sessile drop depends on the refinement of approximation of the above integration.

Quincke[28] made two assumptions in order to put the equation into integrable form: 1) that the drop, if sufficiently large, was planar on top, so that the constant term drops out as $b \to \infty$; 2) that R_2 is very large compared with R_1, so that $\sin\phi/x$ may be neglected. Integration thereby yields:

$$g\rho h^2 = 2\gamma(1 - \cos\Theta)$$

where:

Θ = contact angle between the liquid and solid measured through the liquid.

h = height of drop above base.

Application of this formula to drops of large surface tension and sizes as small as a centimeter in diameter would result in large errors.

If equation (23) is divided by γ/b

$$1/(R_1/b) + \sin\phi/(x/b) = 2 + z\rho g/(\gamma/b)$$

and $a^2 = \gamma/g\rho$; $\beta = b^2/a^2 = b^2g\rho/\gamma$, the following equation results:

$$\frac{b\,(d^2z/dx^2)}{[1 + (dz/dx)^2]^{3/2}} + \frac{\sin\phi}{x/b} = 2 + \frac{\beta z}{b} \qquad (25)$$

Bashforth and Adams[29] devised a numerical method of obtaining values of x/b and z/b for ϕ from 0 to 180°, and for β from 0.1 to 100. They also prepared a table of x/z in terms of β, for ϕ equals 90°. By taking measurements of x and z at the point where $\phi = 90°$ and at the base the following quantities may be determined for a sessile drop: 1) contact angle, 2) volume, 3) surface tension and 4) surface area.

Worthingham[30] presented the following formula, which contains Quincke's equation but also employs a series of approximations intended to reduce the error resulting from Quincke's assumpitons.

$$\gamma = \rho g z^2/2(1 + 0.6094z/r) \qquad (26)$$

where:

ρ = difference in density of glass and air.

r = radius at largest horizontal cross section.

h = height above largest cross section.

(*Continued on page* 482)

BIBLIOGRAPHY OF THERMAL EXPANSION OF GLASSES

By M. D. KARKHANAVALA

Division of Ceramics, Pennsylvania State College, State College, Penna.

PART II

Editor's Note: Throughout this paper, the weight per cent composition of glasses determined by chemical analysis is marked by an asterisk; those not so marked represent the weight per cent composition of the oxide in the batch. If all the compositions investigated by a particular author have been chemically analyzed, the asterisk is placed near the first composition only and all the following compositions credited to that author also represent the weight per cent composition by chemical analysis of the glasses.

TERNARY SYSTEMS

System No.	System	Investigator	Weight Per Cent Composition			Coefficient of Expansion ($\alpha \times 10^7$)	Temperature Range (°C.)
11	Li_2O-Al_2O_3-B_2O_3	A. Winkelmann & O. Schott Ann. Phys. Chem., *51*,730 (1894)	Li_2O	Al_2O_3	B_2O_3		
			6.0	30.0	64.0	56	0-100
12	Na_2O-Al_2O_3-B_2O_3	N. Chandappa & H. E. Simpson Glass. Ind., *32*,505 (1951)	Na_2O	Al_2O_3	B_2O_3		
			32.4	—	67.5	104	50-300
			29.6	3.8	66.7	94	
			27.0	7.4	65.6	90	
			24.4	10.9	64.7	88	
			21.9	14.4	63.9	79	
			19.4	17.7	62.9	69	
			17.0	20.9	62.0	72	
13	Li_2O-Na_2O-SiO_2	H. Sheybany, Verre et Refract., *2*,127 (1948)	Li_2O	Na_2O	SiO_2		
			11	4	85	59	10-300
			7.5	7.5	85	64	
			4	11	85	67	
			19	6	75	97	
			12.5	12.5	75	110	
			6	19	75	120	
			26	9	65	124	
			17.5	17.5	65	133	
			9	26	65	143	
14	Li_2O-K_2O-SiO_2	H. Sheybany, Verre et Refract., *2*,127 (1948)	Li_2O	K_2O	SiO_2		
			11	4	85	57	10-300
			7.5	7.5	85	69	
			4	11	85	78	
			19	6	75	93	
			12.5	12.5	75	105	
			6	19	75	118	
			26	9	65	124	
			17.5	17.5	65	138	
			9	26	65	149	
15	Li_2O-B_2O_3-SiO_2	A. E. Dale, E. F. Pegg & J. E. Stanworth, J. Soc. Glass Tech., *35*,136T (1951)	Li_2O	B_2O_3	SiO_2		
			18	2	80	105	0-300
			18	22	60	98	
			18	42	40	95	
			18	62	20	95	
			18	72	10	95	
16	Li_2O-Al_2O_3-SiO_2	C. E. Brackbill, H. A. McKinstry & F. A. Hummel, J. Amer. Cer. Soc., *34*,107 (1951)		Li_2O	Al_2O_3	SiO_2		
			Li_2O-Al_2O_3-2SiO_2	11.8	40.5	47.7	76.0	30-500
			Li_2O-Al_2O_3-4SiO_2	8.0	27.4	64.6	66.6	
			Li_2O-Al_2O_3-6SiO_2	6.1	20.7	73.2	52.5	
			Li_2O-Al_2O_3-8SiO_2	4.9	16.6	78.5	43.6	
			Li_2O-Al_2O_3-10SiO_2	4.1	13.9	82.0	39.3	
17	Na_2O-K_2O-SiO_2	H. A. Sheybany Verre et Refract., *2*,127 (1948)	Na_2O	K_2O	SiO_2		
			11	4	85	80	10-300
			7.5	7.5	85	85	
			4	11	85	87	
			19	6	75	128	
			12.5	12.5	75	133	
			6	19	75	138	
			26	9	65	167	
			17.5	17.5	65	169	
			9	26	65	170	

System No.	System	Investigator	Weight Per Cent Composition				Coefficient of Expansion ($ax10^7$)	Temperature Range (°C.)
		W. Hanlein Zeitscher. techn. Physik,*14*,418 (1933) (selected compositions taken from graphs)		Na_2O	K_2O	SiO_2		
				32.5	20	47.5	200	at 50
				25	27.5	47.5	200	
				20	32.5	47.5	200	
				40	5	55.0	175	
				25	17.5	57.5	175	
				10	35	55	175	
				30	5	65	150	
				20	15	65	150	
				15	20	65	150	
				20	7.5	72.5	125	
				15	12.5	72.5	125	
				5	25	70	125	
				15	6	79	100	
				10	12	78	100	
				7.5	15	77.5	100	
				10	5	85	75	
				3	15	82	75	
18	Na_2O-BeO-SiO_2	C. A. Becker Sprechsaal, *67*,137-39, 216-8, 233-4 (1934)	$Na_2O.3SiO_2$ xBeO		*Na_2O	BeO	SiO_2		
				x = 0	25.01	—	73.60	113.4	25.90
				0.2	24.23	1.94	72.89	107.8	
				0.25	24.43	2.45	72.12	104.3	
				0.4	23.94	3.84	71.46	103.4	
				0.5	24.34	5.13	69.98	100.9	
				0.6	23.44	5.68	69.98	99.5	
				0.8	22.82	7.59	68.68	99.0	
				1.0	22.07	9.33	67.59	100.2	
				1.2	22.34	10.78	65.90	96.0	
				1.4	22.13	12.55	64.48	93.9	
				1.6	21.73	13.95	63.40	93.8	
				1.8	21.38	15.58	62.12	91.1	
			(1-x) Na_2OxBeO3SiO_2	x=0.1	22.71	1.17	75.08	101.7	25-90
				0.2	20.74	2.16	76.26	90.1	
				0.3	17.52	3.51	78.08	81.4	
				0.4	15.65	4.52	79.26	78.3	
		E. Rencker Bull. Soc. Chim. de France, *2*,1389 (1935)			Na_2O	BeO	SiO_2		
					7.6	6.4	86	45	20-100
					9	4	87	49	
					14	11.5	75.5	66	
					13.2	6.8	80	67	
					16	12	72	80	
					18	10	72	87	
					20	14	66	91	
					28.7	6.6	64.7	116	
					22.4	3.2	74.4	99	
					26.8	11	62.2	111	
					15	11	74	76	
					25.9	2.7	71.4	107	
					19	4	77	90	
					32	11	57	121	
					23.5	7.5	69	102	
		E. Rencker, Compt. rend., *197*,840 (1933) (from triangular graph)			9.5	4.5	86.5	54	20-400
					7.5	6.5	86.0	50	
					12.5	7.5	80.0	74	
					12.5	12.5	75.0	73	
					15.0	11.0	74.0	84	
					19.0	5.0	76.0	100	
					16.0	12.0	72.0	88	
					18.0	10.0	72.0	96	
					20.0	14.0	66.0	100	
					26.5	11.0	62.5	122	
					23.5	7.5	69.0	112	
					31.0	12.0	57.0	133	
					22.5	3.5	74.0	109	
					28.5	7.0	64.5	128	
					26.0	3.0	71.0	118	
19	Na_2O-MgO-SiO_2	C. A. Becker Sprechsaal, *67*,137-39, 216-8, 233-4 (1934)	$Na_2O·3SiO_2$·O·25MgO		Na_2O	MgO	SiO_2		
					*23.68	3.91	71.62	104.7	25-90
			$Na_2O·3SiO_2$·O·50MgO		22.92	7.77	68.52	104.2	
		S. English & W. E. S. Turner J. Soc. Glass Tech., *4*,115T 1920)	(2-x) Na_2O xMgO $6SiO_2$						
			x = 0.1		*24.23	1.10	74.07	111.1	0-90
			0.2		23.46	1.85	74.35	106.4	
			0.3		22.12	2.49	75.00	100.5	
			0.4		20.69	3.47	75.16	94.7	
			0.5		19.83	4.20	75.19	89.5	
			0.6		18.26	5.09	76.30	84.1	
			0.7		16.05	6.10	77.09	78.4	
			0.8		15.77	6.87	76.68	75.4	
			0.9		14.55	7.46	76.86	71.0	
			1.0		13.40	8.45	77.77	64.5	
			1.1		11.76	9.30	78.28	59.4	

System No.	System	Investigator	Weight Per Cent Composition	Na_2O	MgO	SiO_2	Coefficient of Expansion ($\alpha \times 10^7$)	Temperature Range (°C.)
		M. D. Karkhanavala & F. A. Hummel J. Amer. Ceram. Soc., In print	$Na_2O \cdot MgO \cdot xSiO_2$ x = 6	13.4	8.7	77.9	65.0	20-150
			5	15.41	10.02	74.57	69.6	
			4	18.09	11.76	70.15	71.4	
			3	21.94	14.27	63.79	81.4	
			2	27.86	18.12	54.02	83.8	
		E. Rencker Bull. Soc. Chim. de France, 2,1389 (1935)		14.6	27.7	57.7	44	20-100
				19.3	19.6	61.1	84	
				20.1	18.7	61.2	87	
				25.6	11.2	63.2	109	
				10.2	15.9	63.9	86	
				11.7	8.8	79.5	56	
				Na_2O	CaO	SiO_2		
20	Na_2O-CaO-SiO_2	C. A. Becker, Sprechsaal, 67,137-39, 216-8, 233-4 (1934)	$Na_2O \cdot O \cdot 25CaO3SiO_2$	*23.38	5.52	70.85	106.1	25-90
			$Na_2O \cdot O \cdot 5CaO3SiO_2$	21.85	11.04	66.20	107.4	
		S. English & W. E. S. Turner J. Soc. Tech., 3,238T (1919)	(2-x) $Na_2OxCaO6SiO_2$ x = 0.0	*25.34	—	74.05	115.3	25-90
			0.1	23.80	1.50	73.92	110.6	
			0.2	23.00	2.61	74.08	106.5	
			0.3	21.50	3.81	74.07	102.1	
			0.4	20.78	4.50	73.78	98.8	
			0.5	19.38	6.26	73.18	94.7	
			0.6	17.20	7.45	74.41	91.1	
			0.7	16.00	8.16	74.99	87.0	
			0.8	14.88	9.36	74.96	84.4	
			0.9	14.22	10.38	74.59	81.0	
			1.0	13.02	11.68	74.93	76.8	
			$O \cdot 75Na_2O1 \cdot 25CaO4 \cdot 68SiO_2$	11.22	17.38	69.73	80.1	
			$O \cdot 81Na_2O1 \cdot 18CaO3 \cdot 94SiO_2$	12.72	18.17	66.71	88.2	
		M. D. Karkhanavala & F. A. Hummel J. Amer. Ceram. Soc., In print	$Na_2O \cdot CaO \cdot 5SiO_2$	14.82	13.40	71.78	78.2	Rm.t.-150
			$Na_2O \cdot CaO \cdot 4SiO_2$	17.30	15.65	67.05	85.8	
			$Na_2O \cdot CaO \cdot 3SiO_2$	20.78	18.80	60.42	91.0	
			$Na_2O \cdot CaO \cdot 2SiO_2$	26.12	23.44	50.44	95.3	
		N. M. Parikh, M.S. Thesis, New York State College of Ceramics, June 1950	$1 \cdot 2Na_2O\ O \cdot 6CaO\ 3 \cdot 97SiO_2$	21.5	9.7	68.8	98.9	
			$1 \cdot 3Na_2O\ O \cdot 5CaO\ 3 \cdot 97SiO_2$	23.2	8.1	68.7	101.9	
			$1 \cdot 4Na_2O\ O \cdot 4CaO\ 3 \cdot 97SiO_2$	25.0	6.4	68.6	105.2	
			$1 \cdot 5Na_2O\ O \cdot 3CaO\ 3 \cdot 97SiO_2$	26.8	4.7	68.5	108.9	
			$1 \cdot 6Na_2O\ O \cdot 2CaO\ 3 \cdot 97SiO_2$	28.5	3.2	68.3	113.6	
		E. Rencker Bull. Soc. Chim. de France, 2,1389 (1935)		20.4	23.6	56	108	20-100
				30.0	4	66	125	
				23.8	10	66.2	115	
				20.7	13	66.3	105	
				23.0	7	70	110	
				14.4	9	76.6	75	
		B. C. Schmidt, A. N. Finn & J. C. Young Bur. Stand. J. Res., 12,421 (1934)		*27.93	19.83	52.20	157.3	25-400
				32.85	12.78	54.37	165.2	
				34.00	9.80	56.20	178.8	
				23.91	19.75	56.34	136.0	
				37.48	5.76	56.76	178.8	
				38.54	3.05	58.41	181.2	
				19.79	20.06	60.05	130.8	
				25.50	15.18	60.32	138.8	
				17.39	19.68	62.93	114.8	
				24.39	12.27	63.34	138.3	
				21.22	14.64	64.14	125.2	
				26.84	8.46	64.70	138.8	
				28.79	5.50	65.71	141.3	
				17.92	16.03	66.05	117.2	
				13.97	19.91	66.12	106.7	
				21.74	11.79	66.47	130.7	
				11.62	21.15	67.23	98.7	
				29.43	3.27	67.30	141.3	
				22.50	9.52	67.98	125.2	
				15.03	14.85	70.12	104.0	
				23.00	6.50	70.50	120.0	
				12.10	16.20	71.70	93.5	
				14.21	13.71	72.08	96.1	
				24.24	3.15	72.61	122.8	
				15.23	10.68	74.09	96.1	
				12.28	13.03	74.69	88.0	
				15.26	9.26	75.48	96.1	
				18.45	2.99	78.56	101.2	
				16.33	4.90	78.77	90.8	
				16.17	3.24	80.59	85.3	
		E. Seddon & W. E. S. Turner J. Soc. Glass Tech., 17,324T (1933)		*15.38	9.37	75.25	84.3	0-100
		E. Seddon, W. E. S. Turner & F. Winks, J. Soc. Glass Tech., 18,5T (1934)		*12.00	12.04	75.94	74.4	0-75
				15.38	9.37	75.25	84.4	
				18.39	6.91	74.70	91.6	

System No.	System	Investigator	Weight Per Cent Composition				Coefficient of Expansion ($\alpha \times 10^7$)	Temperature Range (°C.)
20 *(Continued)*			Na_2O	CaO	SiO_2			
			19.91	4.80	74.85		99.8	
			22.66	2.69	74.65		105.4	
			11.74	12.26	76.00		72.3	
			13.99	10.21	75.80		79.6	
			10.52	8.07	81.19		65.8	
			15.45	10.01	74.07		85.8	
			15.49	14.08	70.27		89.8	
			16.96	10.06	72.87		89.5	
			15.00	14.41	70.64		87.4	
			14.91	11.85	73.21		83.4	
		W. B. Silverman	11	8	81	76		80-170
		J. Soc. Glass Tech.,	13	8	79	84		
		24,59T (1940)	15	8	77	91		
			17	8	75	99		
			11	10	79	78		
			13	10	77	85		
			15	10	75	93		
			17	10	73	100		
			11	12	77	80		
			13	12	75	87		
			15	12	73	95		
			17	12	71	102		
			11	14	75	82		
			13	14	73	88		
			15	14	71	96		
			17	14	69	103		
			11	16	73	83		
			13	16	71	90		
			15	16	69	97		
			17	16	67	105		
			*12.7	7.9	78.8	80		
			14.3	7.9	77.4	89		
			15.3	7.8	76.3	93		
			17.0	7.9	74.4	98		
			19.0	8.0	72.3	104		
			11.0	11.7	77.0	80		
			12.7	11.8	75.0	84		
			14.2	11.8	73.7	92		
			15.5	11.8	72.3	97		
			17.0	11.7	70.7	102		
			10.8	15.8	72.7	83		
			12.6	15.9	71.2	87		
			14.1	15.7	69.5	93		
			15.5	15.7	68.3	99		
			17.2	15.8	66.4	106		
			18.9	15.8	64.5	112		
21	Na_2O-SrO-SiO_2	M. D. Karkhanavala &	$1Na_2O$ 1SrO $xSiO_2$	Na_2O	SrO	SiO_2		
		F. A. Hummel	x = 5	13.3	22.2	64.5	83.1	Rm.t.
		J. Amer. Ceram. Soc.	4	15.3	25.5	59.2	84.1	to
		In print	3	17.9	29.5	52.0	85.0	150°
			2	21.7	36.2	42.1	105.0	
22	Na_2O-BaO-SiO_2	S. English & W. E. S. Turner	$(2-x)Na_2O$ $xBaO$ $6SiO_2$	Na_2O	BaO	SiO_2		
		J. Soc. Glass Tech.,	x = 0.1	*23.30	3.03	72.86	110.2	0-100
		11,425T (1927)	0.2	21.95	5.98	71.46	106.8	
			0.3	20.91	8.59	70.83	104.8	
			0.4	19.49	11.07	68.72	103.4	
			0.5	17.39	14.16	68.33	100.1	
			0.6	15.89	17.28	66.33	95.0	
			0.7	14.98	19.38	64.94	95.6	
			0.8	12.52	22.37	63.18	88.8	
			0.9	11.72	24.25	62.67	88.4	
		L. D. Fetterolf & C. W.		34	6	60	97.5	
		C. W. Parmelee		28	12	60	100.6	
		J. Amer. Ceram. Soc.,		22	18	60	87.4	
		12,193 (1929)		16	24	60	81.4	
				10	30	60	67.0	
		M. D. Karkhanavala &	Na_2O·BaO $xSiO_2$					
		F. A. Hummel	x = 5	12.0	29.7	58.3	93.0	Rm.t.
		J. Amer. Ceram. Soc.,	4	13.6	33.6	52.8	97.0	to
		In print	3	15.7	38.8	45.5	98.6	150°
			2	18.5	45.7	35.8	100.2	
		N. Yasuhara, J. Japan Ceram.						
		Assoc., *50*, (590), 61 (1942)		20	5	75	90	50-300
				15	10	75	91	
				25	5	70	99	
				20	10	70	99	
				15	15	70	98	
				10	20	70	90	
				30	5	65	112	

System No.	System	Investigator	Weight Per Cent Composition			Coefficient of Expansion ($\alpha \times 10^7$)	Temperature Range (°C.)
22 *(Continued)*			Na_2O	BaO	SiO_2		
			25	10	65	106	
			20	15	65	111	
			15	20	65	100	
			10	25	65	91	
			5	30	65	76	
			35	5	60	151	
			30	10	60	147	
			25	15	60	117	
			20	20	60	116	
			15	25	60	112	
			10	30	60	99	
			5	35	60	87	
			30	15	55	111	
			25	20	55	134	
			20	25	55	123	
			15	30	55	116	
			10	35	55	107	
			5	40	55	97	
			20	30	50	131	
			15	35	50	129	
			10	40	50	118	
			5	45	50	102	
23	Na_2O-ZnO-SiO_2	S. English, W. E. S. Turner & F. Winks, J. Soc. Glass Tech., *12*,287T (1928)	(2-x) Na_2O x ZnO 6SiO_2				
			x = 0.1				
			0.2				
			0.3				
			0.4				
			0.5				
			0.6				
			0.7				
			*24.07	1.29	74.09	108.1	25-90
			21.89	3.51	73.48	101.6	
			20.63	4.55	73.52	95.9	
			19.48	6.12	73.36	91.7	
			17.07	6.70	75.06	84.2	
			17.20	9.54	72.11	87.5	
			15.40	11.13	72.46	77.9	
		L. D. Fetterolf & Parmelee, J. Amer. Ceram. Soc., *12*,193 (1929)	34	6	60	111.0	0-100
			28	12	60	100.6	
			22	18	60	81.4	
			16	24	60	66.8	
			10	30	60	46.6	
		E. Rencker Bull. Soc. Chim. de France, *2*,1389 (1935)	19.4	32.2	47.4	93	20-100
			25.3	24.3	50.4	114	
			22.3	22.7	55.0	103	
			28.1	14.6	57.3	118	
			19.7	6.1	74.2	86	
			5.9	12.4	81.7	61	
24	Na_2O-B_2O_3-SiO_2	S. English & W. E. S. Turner J. Soc. Glass Tech., *7*,155T (1923)	*19.78	4.46	74.22	84.0	25-90
			18.76	8.28	71.56	81.7	
			18.92	11.34	68.39	81.3	
			19.95	14.45	64.72	83.7	
			18.93	18.84	61.28	80.5	
			20.36	28.83	50.04	81.4	
			11.26	12.45	74.91	57.8	
			9.79	18.71	70.75	49.8	
			10.13	21.81	67.18	49.7	
			11.19	25.82	61.94	52.1	
			9.55	31.26	57.87	54.2	
			10.34	36.17	52.11	55.7	
			10.44	42.33	46.30	57.0	
			11.49	46.07	41.29	60.6	
		E. J. Gooding & W. E. S. Turner J. Soc. Glass Tech., *18*,32T (1934)	Na_2O	B_2O_3	SiO_2		
			43.29	7.63	49.00	152.5	0-130
			39.27	14.86	45.52	141.9	
			37.33	21.59	40.64	130.2	
			34.24	31.29	34.67	114.5	
			25.48	21.36	53.24	99.9	
			23.38	25.11	51.61	100.7	
			20.59	36.05	43.20	77.8	
			24.50	41.92	33.44	94.0	
			25.47	48.89	25.72	74.8	
			9.16	55.51	35.38	64.3	
			23.64	57.01	19.18	73.4	
			16.75	70.24	13.22	84.1	
			7.13	81.43	11.57	82.7	
			7.25	89.80	3.01	92.9	
			1.95	95.00	2.86	115.8	
			37.62	42.32	20.95	138.8	
			34.32	34.76	30.83	128.5	
			26.32	31.28	42.58	110.4	
			20.63	26.65	52.94	85.5	
			16.98	16.80	66.05	72.4	
			11.34	14.50	74.56	62.4	
			9.10	9.74	80.00	50.3	

System No.	System	Investigator	Weight Per Cent Composition			Coefficient of Expansion ($\alpha \times 10^7$)	Temperature Range (°C.)
24 *(Continued)*			Na_2O	B_2O_3	SiO_2		
			5	90	5	101	0-100
			10	85	5	89	
			15	80	5	83	
			20	75	5	83	
			25	70	5	89	
			30	65	5	97	
			5	85	10	100	
			10	80	10	80	
			15	75	10	76	
			20	70	10	78	
			25	65	10	85	
			30	60	10	98	
			5	80	15	85	
			10	75	15	78	
			15	70	15	75	
			20	65	15	77	
			25	60	15	81	
			30	55	15	93	
			35	50	15	113	
			5	75	20	82	
			10	70	20	76	
			15	65	20	73	
			20	60	20	74	
			25	55	20	81	
			30	50	20	99	
			35	45	20	117	
			5	70	25	78	
			10	65	25	73	
			15	60	25	70	
			20	55	25	76	
			25	50	25	84	
			30	45	25	102	
			35	40	25	136	
			5	65	30	73	
			10	60	30	67	
			15	55	30	70	
			20	50	30	76	
			25	45	30	87	
			30	40	30	101	
			35	35	30	130	
			5	60	35	66	
			10	55	35	64	
			15	50	35	67	
			20	45	35	78	
			25	40	35	93	
			30	35	35	117	
			35	30	35	118	
			40	25	35	122	
			5	55	40	59	
			10	50	40	59	
			15	45	40	69	
			20	40	40	82	
			25	35	40	102	
			30	30	40	107	
			35	25	40	119	
			40	20	40	134	
			5	50	45	54	
			10	45	45	59	
			15	40	45	69	
			20	35	45	85	
			25	30	45	95	
			30	25	45	110	
			35	20	45	127	
			40	15	45	142	
			45	10	45	151	
			5	45	50	49	
			10	40	50	47	
			15	35	50	67	
			20	30	50	82	
			25	25	50	101	
			30	20	50	117	
			35	15	50	129	
			40	10	50	140	
			45	5	50	153	
			5	40	55	48	
			10	35	55	55	
			15	30	55	66	
			20	25	55	81	
			25	20	55	101	
			30	15	55	116	

System No.	System	Investigator	Weight Per Cent Composition			Coefficient of Expansion ($\alpha \times 10^7$)	Temperature Range (°C.)
24 *(Continued)*			Na_2O	B_2O_3	SiO_2		
			35	10	55	131	
			40	5	55	147	
			5	35	60	46	
			10	30	60	53	
			15	25	60	66	
			20	20	60	80	
			25	15	60	101	
			30	10	60	119	
			35	5	60	138	
			5	30	65	42	
			10	25	65	52	
			15	20	65	71	
			20	15	65	84	
			25	10	65	105	
			30	5	65	123	
			5	25	70	40	
			10	20	70	49	
			15	15	70	69	
			20	10	70	82	
			25	5	70	104	
			5	20	75	34	
			10	15	75	53	
			15	10	75	67	
			20	5	75	84	
			5	15	80	36	
			10	10	80	50	
			15	5	80	68	
			5	10	85	31	
			10	5	85	33	
			5	5	90	33	
		M. O. Samsoen Ann. Physique, *9*,35 (1928)	*19.78	4.46	74.22	105.3	0-90
			18.76	8.28	71.56	71.9	
			18.92	11.34	68.38	82.3	
			19.95	14.45	64.72	87.0	
			18.83	18.84	61.28	89.1	
			20.30	28.83	50.04	96.3	
			23.71	39.99	35.22	98.3	
		R. Wenig & E. Zchimmer Sprechsaal, *62*,855,874, 889 (1929)	*31.86	4.33	63.81	133.3	at 15
			30.15	8.28	61.57	125.7	
			29.14	11.33	59.53	118.1	
			28.29	18.05	53.66	115.1	
			27.25	17.60	55.15	110.8	
			25.97	18.29	55.14	105.2	
			5.05	14.63	80.32	33.1	
			4.72	19.99	75.29	33.9	
			4.45	23.78	71.77	37.1	
			14.75	10.76	74.49	71.0	
			14.33	14.24	71.43	69.9	
			14.47	19.94	65.59	70.0	
			14.14	23.92	61.94	69.1	
			24.39	10.12	65.49	105.4	
			24.16	14.57	61.27	100.9	
			24.11	20.17	55.72	100.7	
			24.14	24.86	51.00	100.4	
			18.33	4.68	76.99	88.2	
			17.91	8.71	73.38	83.3	
			17.16	12.79	70.05	78.8	
			16.16	16.29	67.55	74.0	
			15.02	19.33	65.65	72.1	
			15.16	22.80	62.04	72.3	
25	Na_2O-Al_2O_3-SiO_2	C. A. Becker, Sprechsaal, *67*,137-39,216-8,233-4(1934)	Na_2O	Al_2O_3	SiO_2		
			*21.06	9.82	68.53	95.7	25-90
			20.11	17.88	61.48	83.2	
		V. Dimbleby, S. English, F. W. Hodkin & W. E. S. Turner, J. Soc. Glass Tech., *8*,173T (1926)	*17.96	0.17	81.34	84.9	25-90
			18.22	6.46	75.12	85.4	
			18.79	8.96	72.19	85.8	
			18.56	10.49	70.76	87.7	
			18.08	15.54	66.17	86.1	
			17.95	19.69	62.25	86.2	
			14.26	6.53	79.21	72.9	
			14.71	10.64	74.72	72.3	
			15.28	12.69	71.56	71.0	
			14.43	15.50	69.99	72.9	
		S. English & W. E. S. Turner J. Soc. Glass Tech., *5*,183T (1921)	Na_2O	Al_2O_3	SiO_2		
			*22.68	2.72	74.30	108.8	25-90
			22.20	4.25	73.30	102.0	
			20.62	6.85	72.05	93.9	
			18.79	8.96	72.19	81.1	

System No.	System	Investigator	Weight Per Cent Composition				Coefficient of Expansion ($\alpha \times 10^7$)	Temperature Range (°C.)
25 *(Continued)*			Na_2O	Al_2O_3	SiO_2			
			16.61	10.71	72.27	76.4		
			15.28	12.69	71.56	71.0		
		C. A. Faick, J. C. Young, D. Hubbard & A. N. Finn J. Res. Natl. Bur. Std., *14*,133 (1935)	*7.00	42.43	50.57	194.3	25 to 447	
			6.71	42.43	50.86	198.5	447	
			9.57	39.54	50.89	190.5	455	
			4.88	44.17	50.95	205.5	435	
			9.83	34.92	55.25	168.1	477	
			6.94	37.50	55.56	178.8	457	
			2.88	41.32	55.80	190.1	440	
			4.83	39.23	55.86	187.9	445	
			4.86	34.46	60.68	168.1	465	
			2.82	36.42	60.76	175.2	455	
			9.59	29.53	60.88	146.3	495	
			1.02	34.20	64.78	167.0	458	
			9.96	24.94	65.10	134.4	510	
			4.75	24.55	65.70	156.5	475	
			9.43	24.69	65.88	129.1	505	
			2.87	31.23	65.90	161.8	470	
			2.03	31.61	66.36	151.0	470	
			6.75	25.45	68.10	134.5	493	
			0.97	29.04	69.99	156.5	470	
			2.03	27.86	70.11	144.2	476	
			4.86	24.84	70.30	129.6	490	
			4.92	24.45	70.63	131.1	490	
			6.49	22.63	70.88	121.5	500	
			9.32	19.60	71.08	108.9	522	
			4.69	21.50	73.81	111.1	502	
			1.07	23.98	74.95	132.0	481	
			2.00	23.02	74.98	124.1	490	
			5.12	19.67	75.21	101.1	502	
			2.85	21.54	75.61	116.0	495	
		E. Rencker, Bull. Soc. Chim. de France Series 5, 2,1389 (1935)	25.7	8.3	66	102	20-100	
			14.6	9.5	76	68		
			33.8	7.8	58.4	136		
			30.1	14.3	55.6	115		
			16	16	68	75		
			18.2	10.9	70.9	81		
			26.6	4.5	68.9	107		
			24.2	13.3	62.5	95		
			21	5.9	73.1	85		
			14.4	14.5	71.1	64		
			29	5	66	117		
			22.5	12.2	65.3	91		
			17.9	10.2	71.9	80		
			17	15	68	76		
			22.6	17	60.4	90		
			18	16	66	82		
			36.2	14.1	49.7	146		
			26.5	18.5	56	103		
			19.2	19.8	61	85		
			16.8	26.2	57	84		
			12.9	22.1	65	75		
			18	28.6	53.4	90		
			23.9	25.8	50.3	90		
			15.9	21.1	63	78		
			19.2	23.8	57	93		
			20.3	23.5	56.2	93		
			18.9	34.3	46.8	80		
			17.8	36.7	45.5	80		
			20	37	43	77		
26	Na_2O-TiO_2-SiO_2	A. R. Sheen & W. E. S. Turner J. Soc. Glass Tech., *8*,187T (1924)	(2-x) $Na_2OxTiO_26SiO_2$			Na_2O	TiO_2	SiO_2		
			x = 0.1			*23.68	1.94	73.42	103.5	25-90
			0.2			23.16	3.01	72.88	99.0	
			0.3			21.82	4.95	72.82	90.3	
			0.4			18.78	6.88	73.30	87.4	
			0.5			16.31	10.03	72.61	80.7	
			0.6			11.90	14.91	73.41	61.9	
27	Na_2O-ZrO_2-SiO_2	V. Dimbleby, S. English, F. W. Hodkin, E. M. Firth & W. E. S. Turner J. Soc. Glass Tech., *11*,52T (1927)	(2-x) $Na_2OxZrO_26SiO_2$			Na_2O	ZrO_2	SiO_2		
			x = 0.05			*24.70	0.95	73.77	110.6	25-90
			0.1			22.60	2.67	74.14	102.8	
			0.15			22.15	3.54	72.80	100.6	
			0.2			20.69	4.67	72.88	96.1	
			0.25			20.12	5.39	72.96	93.5	
			0.3			19.32	6.97	71.89	88.5	
			0.35			18.90	8.25	71.97	84.4	
			0.4			16.89	10.33	72.10	80.8	
			$2Na_2OxZrO_2(6-x)SiO_2$							
			x = 0.25			*22.45	5.35	71.01	101.5	
			0.5			21.40	11.13	65.59	93.5	

(Continued on page 480)

STANDARDS OF TEMPERATURE

By R. E. Wilson, Chief,

Temperature Measurements Section, National Bureau of Standards, Washington, D. C.

As a result of the increasing need for reliable temperature measurements at both very high and very low temperatures, the National Bureau of Standards is extending its temperature standardization program toward the extremes of the temperature scale. New instruments and methods of calibration are being developed for these regions, and research efforts are being directed toward the extension of the International Temperature Scale to provide greater accuracy and reproducibility in the measurements thus made possible.

While the accurate measurement of temperature has long been of interest to the research scientist, its importance, particularly at the extreme ends of the scale, has greatly increased with the rapid technical developments of recent years. During this period, many improvements in processes for the production of steel, glass, gasoline and other important commodities have resulted from the increased precision that is being attained in the measurement and control of temperature. In aeronautics there are new temperature problems in connection with the use of jet propulsion and the operation of aircraft at high altitudes and in polar regions. To attain the desired performance in jet engines, fundamental research is required to develop methods of measuring temperatures of flames and to develop temperature-sensitive devices for indicating performance and controlling operation. For use at jet-engine temperatures as well as in arctic cold, mechanical parts must be specially designed using materials capable of withstanding these extremes in order to function satisfactorily. Likewise, as a result of the applications of atomic energy, it has become necessary to learn more about the heat-transfer properties of a variety of materials at increasingly high temperatures. For effective research in these fields, temperatures must be accurately measured, and the results of one laboratory must be comparable with those of another.

To provide a fundamental basis for precise temperature measurements, a scale of temperature has been established which covers the range from the boiling point of oxygen to the highest temperatures of incandescent bodies and flames. This scale, known as the International Temperature Scale, is based on six reproducible equilibrium temperatures, or "fixed points," to which numerical values are assigned, and upon specified interpolation formulas relating temperature between or above these points to the indications of standard temperature measuring instruments.

The International Temperature Scale was first adopted in 1927 to provide a scale which would conform as closely as possible to a thermodynamic scale proposed many years earlier by Lord Kelvin. The scale which he proposed was based on a relation between the efficiency of a reversible heat engine and the temperatures between which the engine operates. This scale is independent of the working substance in the engine. Temperatures on this scale are identical with those appearing in the ideal gas law and other thermodynamic relations. By observing the change of pressure with temperature of a constant volume of gas, or the change in volume of a quantity of gas under constant pressure, and applying a correction for the imperfection of the gas, temperatures on the thermodynamic (Kelvin) scale can be determined. In practice, however, the complexity of an accurate gas thermometer and the difficulty of making highly precise measurements with it are severe limitations on its use.

The experimental difficulties involved in measuring temperature on the thermodynamic scale and the importance of measuring temperature with high precision on the same scale in all countries ultimately led to the establishment of the International Temperature Scale of 1927. This scale, proposed by the national laboratories of the United States, Great Britain and Germany, and adopted by 31 nations, was designed to conform as nearly as practicable to the thermodynamic scale as it was then known. It has always been possible to obtain values of temperature on the International Temperature Scale more accurately than on the thermodynamic scale.

The International Temperature Scale of 1927 proved useful in providing a stable, uniform and precise basis for obtaining temperatures. However, in the 20 years following its adoption, the increasing precision attained in temperature measurements made it apparent that some revision was desirable in order to make the scale more self-consistent and to improve its agreement with the thermodynamic scale. The major responsibility for proposing and obtaining agreement on the changes fell to the National Bureau of Standards. After many consultations with scientists and laboratories in this country and abroad, the Bureau prepared a draft that formed the basis of the document finally adopted at Paris by the Ninth General Conference on Weights and Measures as "the International Temperature Scale of 1948".[1,2] On January 1, 1949, the Bureau began using the definitions of the 1948 scale, both in its own research program and in calibrating instruments for other scientific and industrial purposes.

The six fixed points of the 1927 scale were the boiling point of oxygen (—182.97°C.), the freezing and boiling points of water, the boiling point of sulfur (+444.60°C.), the melting point of silver (+960.5°C.) and the melting point of gold (+1,063°C.). From —190° to +660°C., the measurement of temperature was based on the indications of a standard platinum resistance thermometer used in accordance with specified formulas; from +660°C. to the gold point, the platinum versus platinum-10% rhodium thermocouple was standard; and above 1063°C., the optical pyrometer was used.

The same fixed points, with one slight modification, are specified in the 1948 scale, and the instruments and interpolation equations for obtaining temperatures between fixed points are essentially the same as those previously used. Only two revisions in the definition of the scale resulted in appreciable changes in the numerical values assigned to measured temperatures. One of these was the change in the value for the silver point from 960.5° to 960.8°C., which made numerical values of temperatures measured with the standard thermocouple in the range between 630° and 1,063°C. somewhat higher, the maximum difference being about 0.4 degree

near 800°C. The other change was the adoption of a new value (1.438 cm-deg) for the constant c_2 in the radiation formula used to calculate temperatures above the gold point as observed with an optical pyrometer. Also, in the new scale, Planck's radiation formula is specified instead of Wien's for calculating these temperatures. Since Planck's law is consistent with the thermodynamic scale even at high temperatures, this change removed the upper limit to the scale formerly imposed by the use of Wien's law.

The International Temperature Scale is commonly used from its lowest limit, the normal boiling point of oxygen (—182.97°C. or 90.19°K.), to the highest temperatures measured. For temperatures below the oxygen point down to about 10°K., the Bureau maintains an auxiliary scale based on the resistance of capsule-type platinum resistance thermometers, some of which were calibrated using a helium gas thermometer. At the time it was established, this scale was made to agree with the thermodynamic scale as closely as possible. Capsule-type resistance thermometers are calibrated on this scale by the NBS for laboratories in the United States and in foreign countries.

In connection with maintenance of the International Temperature Scale, the Bureau calibrated the three standard instruments—platinum resistance thermometers, platinum-platinum rhodium thermocouples and optical pyrometers—and certifies them for other laboratories throughout the Nation. These laboratories then use the calibrated instruments as working standards for the calibration of other temperature-measuring instruments. In addition to the working standards, other thermocouples as well as liquid-in-glass thermometers and ribbon-filament lamps are certified by NBS. Standard resistance thermometers and thermocouples are used to determine the temperature of the testing baths and furnaces. Some types of liquid-in-glass thermometers are also calibrated against standard resistance thermometers and are then used as working standards to calibrate other liquid-in-glass thermometers. Approximately 2500 temperature-measuring instruments — optical pyrometers, ribbon-filament lamps, resistance thermometers, thermocouples, and liquid-in-glass thermometers—are certified each year for Federal agencies, State and municipal governments, industrial laboratories and manufacturers. About 48,000 clinical thermometers, a sampling of a much larger number, are also tested each year for the Veterans' Administration, the U. S. Public Health Service and the U. S. Department of Agriculture to insure compliance with specifications. As a result of this standardizing service, practically all measurements of temperatures above the oxygen point in this country are based upon the International Temperature Scale as established and maintained by NBS.

Calibration of a standard platinum resistance thermometer throughout its range is carried out by measuring the resistance of the thermometer at the oxygen point, the ice point, the steam point and the sulfur point. From these data, constants are calculated for the interpolation equation which gives the resistance of the thermometer at any given temperature in terms of that temperature and the resistance at 0°C. The International Temperature Scale specifies that the platinum in the

Fig. 1. Experimental high-temperature calibration of a thermocouple in the National Bureau of Standards pyrometry laboratory. An optical pyrometer is being used to determine the temperature of the thermocouple hot junction, which is contained in a graphite crucible within a radio-frequency heating coil (center). The cold junction is kept in an ice bath within the dewar to the right of the heating coil.

Table 1. Fixed points[a] of the International Temperature Scale of 1948.

Fixed point	Temperature
	°C.
Oxygen point	—182.97
Temperature of equilibrium between liquid oxygen and its vapor	
Ice point (fundamental fixed point)	0.00
Temperature of equilibrium between ice and air-saturated water	
Steam point (fundamental fixed point)	100.00
Temperature of equilibrium between liquid water and its vapor	
Sulfur point	444.60
Temperature of equilibrium between liquid sulfur and its vapor	
Silver point	960.80
Temperature of equilibrium between solid and liquid silver	
Gold point	1,063.00
Temperature of equilibrium between solid and liquid gold	

[a]Under the standard pressure of 1,013,250 dynes/cm².

standard resistance thermometer must be annealed and must have a purity such that the ratio $\frac{R100}{R0}$ is greater than 1.3910.

The standard thermocouple, which must contain platinum of high purity and must satisfy certain specific requirements concerning the electromotive force it develops, is calibrated by measuring its electromotive force when one junction is maintained successively at a temperature between 630.3°C. and 630.7°C. (as determined by a standard resistance thermometer), at the silver point and at the gold point. The reference junction of the thermocouple is held at 0°C. These three values of the electromotive force permit the calculation of the three constants in a quadratic equation which relates electromotive force to the corresponding temperature.

Optical pyrometers are used to measure the temperature of incandescent bodies by visual comparison of a portion of the radiation from the hot body with that emanating from an incandescent lamp filament. Calibration of such an instrument involves a determination of the pyrometer lamp current which corresponds to a stated temperature. This is done at NBS by comparison of the pyrometer under study with a previously calibrated standard pyrometer, both instruments being sighted upon a ribbon-filament lamp which serves as a source of constant temperature.

The current-temperature relation for the standard pyrometer is determined by means of Planck's law of radiation. In this process the pyrometer lamp current corresponding to the gold point (1,063°C.) is first determined by matching the brightness of a portion of the lamp filament with that of a black body immersed in freeing gold. The calibration is extended above the gold point by using a ribbon-filament lamp and sector disks. The temperature of the ribbon-filament lamp is first adjusted until its brightness, when viewed through a given rotating sector disk, is equal to that of a black body at the gold point. From the known fractional transmission of the sector disk, the brightness temperature of the lamp itself, without the disk, is calculated by means of Planck's law. The sector disk is then removed, and the pyrometer lamp current is increased to obtain a brightness match between the pyrometer lamp and the ribbon-filament lamp. When this match is obtained, the pyrometer current corresponds to the calculated temperature. In order to be able to calibrate commercial pyrometers below the gold point, the calibration of the standard pyrometer is extended to lower temperatures by inserting, in turn, various rotating sector disks between the pyrometer and the gold-point black body and observing the pyrometer lamp current required to match the resulting reduced brightness. The corresponding temperatures below the gold point are then calculated from the fractional transmissions of the various sectors and Planck's law of radiation. By use of sector disks with different angular openings, the pyrometer lamp currents for various temperatures on either side of the gold point are determined, and a complete calibration is obtained by interpolation.

The most commonly used fixed point in thermometry is the ice point, which is defined as the temperature of equilibrium at a pressure of one atmosphere between ice and air-saturated water. In practice, this definition is difficult to realize exactly because all impurities except air (the composition of which is not specified) must be absent and because complete saturation by air is difficult to attain. Fortunately, the effects of these factors are small except in measurements demanding the highest precision. When the ice point was first defined, the ice bath, made of finely divided pure ice and distilled water exposed to the atmosphere, was assumed to be sufficiently accurate to fix the ice-point temperature within 0.001 degree C. Later, however, when an accuracy of 0.0001 degree C. was desired, a more reproducible standard became necessary. The Bureau therefore began investigation of the triple point of water, defined as the temperature at which ice, liquid water and water vapor are in equilibrium. As a result of this work, a special apparatus known as a triple-point cell[4] was designed for determination of the triple point, and the triple point is now used by the Bureau instead of the ice point for high-precision measurements.

Fig. 2. Liquid-in-glass thermometers are shown being tested at the National Bureau of Standards by comparison with one of the Bureau's standard platinum resistance thermemeters. For the temperature range from 0° to 100°C., the thermometers are immersed in a mechanically stirred water bath. The power input to the heater is controlled by the variable transformer at the left of the bath. The thermometers under test are read with a telescope, and the corresponding reading for the platinum-resistance thermometer is obtained with a Mueller thermometer bridge.

The triple-point cell consists of a cylindrical glass container having a coaxial re-entrant well for a thermometer. Very pure air-free water is sealed in the cell, partially filling it. The NBS technique in preparing a cell for use is to freeze a mantle of ice along the thermometer well. This method further purifies the ice adjacent to the thermometer well. A thin layer of ice is then melted to provide the interface between pure water and pure ice, both of which are in contact with the vapor phase. Experiments[5] carried out in 1942 showed that the triple

(*Continued on page* 486)

Inventions and Inventors

Glass Compositions

Optical Glass. Fig. 1. Patent No. 2,606,841. Filed May 31, 1949. Issued Aug. 12, 1952. One sheet of drawings. Assigned to Corning Glass Works by William H. Armistead.

This patent relates back to another patent to Armistead, No. 2,435,995, and is directed particularly to an optical glass having an index of refraction for the D line (nD) greater than 1.60 and dispersive indices (v) higher than have heretofore been obtainable in a flint glass. The patent gives 11 examples given in per cent by weight, as calculated from the batches, of compositions coming within the scope of this patent as follows:

	A	B	C	D	E	F	G	H	I	J	K
BaO	25	20	44	43	50	25	40	60	45	45	20
CdO	25	20	17	17	12	35	25	15	30	30	40
PbO	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	20
Al_2O_3	.....	10	15.5	10	10	10	5	5	5	.....	2
B_2O_3	.....	10	23	16	8	15	10	10	10	10	7
SiO_2	40	30	.....	13	19	15	20	10	10	10	7
K_2O	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Na_2O	.....	.....	.5	1	1	.....	.....	.....	.....	5	2
*n*D	1.6105	1.6323	1.6530	1.6534	1.6538	1.6697	1.6777	1.6997	1.7179	1.7417	1.8712
v	49	47	50.3	50.7	50.6	47	50	46	43	41	26

The diagram of the figure shows these glasses as coming above the lines X and Y which represent the approximate minima in values for nD and v characteristic of this invention.

The patent contains eight claims and the only reference cited was Patent No. 2,477,649 dated Aug. 2, 1949, to Pincus.

Tube and Cane Machines

Tube Cutting Machine. Fig. 2. Patent No. 2,603,038. Filed July 11, 1945. Issued July 15, 1952. One sheet of drawings. Assigned to Westinghouse Electric Corporation by Michael E. McGowan.

The tubing comes into the machine at the left of the figure where it is gripped by clamping jaws 17 mounted on a carriage 13, together with a ring burner 15. This carriage moves to the right until the forward end of the tube actuates a mercury switch device 29 whereupon the cracking device 27 breaks off the desired length of tubing. The cut lengths are carried off on a cross conveyor. Mechanism is provided to actuate the clamping jaws and other parts and to provide means for adjusting the length of tubing to be cut. Thus the reciprocation of the carriage advances the tubing, causes it to be cut and deposited on the cross conveyor.

The patent contains three claims and nine references were cited: 1,220,201, Danner, Mar. 27, 1917; 1,710,898, Rowley, Apr. 30, 1929; 1,744,045, Halbach, Jan. 21, 1930; 1,765,814, Wright, June 24, 1930; 2,221,788, Doyle, Nov. 19, 1940; 2,310,469, Snyder, Feb. 9, 1943; 2,323,182, Stuckert, June 29, 1943; 2,521,352, Dockerty et al., Sept. 5, 1950; and 685,758, France, Apr. 7, 1930.

Tube Drawing Machine. Fig. 3. Patent No. 2,604,733. Filed July 17, 1950. Issued July 29, 1952. Two sheets of drawings. Assigned to General Electric Company by Adrien F. Casler.

This is a machine for drawing tubing from a gather on a blow pipe. The tube 1, which is almost completely hardened, is engaged between three pairs of wheels arranged one above the other, being numbered 2, 3; 4, 5; and 6, 7. It will be seen that the axes of each pair of wheels are at an angle to each other as shown in the plan view of the figure. These draw the tube at a speed of at least 2,000 feet per minute. The surface of these wheels is covered with a resilient material, such as silicone rubber, and this arrangement causes the tube to be twisted around its axis as it passes between the several pairs of wheels and thus perfect the shape of the tube

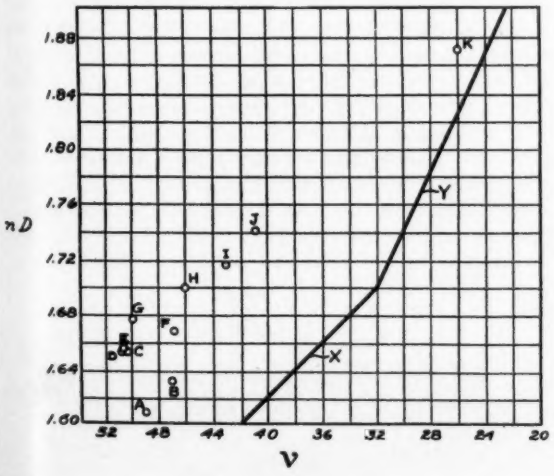


Fig. 1. Optical Glass.

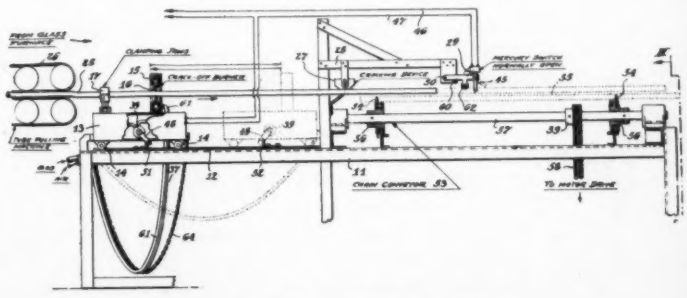


Fig. 2. Tube Cutting Machine.

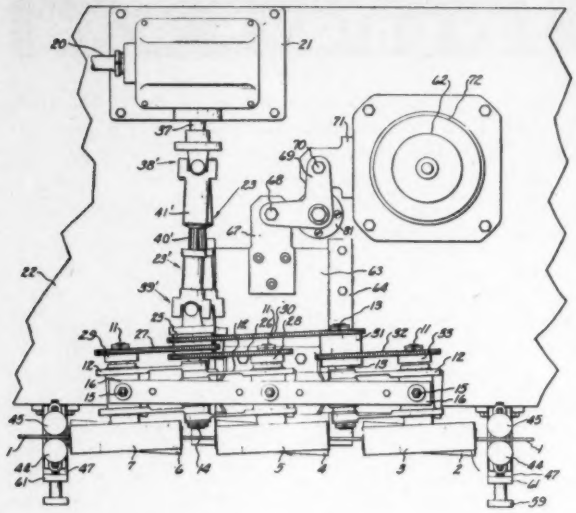


Fig. 3. Tube Drawing Machine.

before it leaves the last pair of wheels. Guide rolls 44 and 45 are provided at each end of the pairs of wheels.

The necessary driving means for the wheels and means for adjustment of the working parts are shown in the patent. The patent contains five claims and the references cited were 1,220,201, Danner, Mar. 27, 1917; 1,702,969, Helland, Feb. 19, 1929; 2,009,326, Sanchez-Vello, July 23, 1935; 2,024,447, Hendrickson, Dec. 17, 1935; 2,438,448, Morton et al., Mar. 23, 1948; 2,525,590, Collins, Oct. 10, 1950; and 1949 *Modern Plastics Encyclopedia* and *Engineer's Handbook*, pages 252 and 253, published by Plastics Catal. Corp., New York.

Miscellaneous Processes

Cast Refractory. Patent No. 2,603,914. Filed Mar. 5, 1948. Issued July 22, 1952. No drawings. Assigned to Corhart Refractories Company by T. E. Field and H. T. Smyth.

This is a method of making heat cast refractories and, while the patent does not mention glass in any way, it might be assumed that the product is designed particularly for contact with molten glass.

An earlier patent to these inventors, No. 2,381,945, discloses a method of avoiding the large central void or pipe caused by the decrease in volume on conversion of the molten liquid into a crystalline solid on cooling. This was done by slowly pouring a granular gasifier onto the surface of the molten refractory stream while it was being poured.

According to the present patent, it has been found that excellent pipe distribution can be obtained in relatively deep molds if the gasifier is placed in kraft paper envelopes attached to the interior face of the top of the mold and the mold is cast rapidly. In a rapid pour, an inch of metal may form in the bottom of even a large mold within 5 seconds and apparently even kraft paper will hold the gasifier long enough for at least a thin layer of metal to cover the bottom of the mold before the gasifier is released.

The patent contains seven claims and the references cited were 786,009, Cowden, Mar. 28, 1905; 1,975,084, Davies, Oct. 2, 1934; 2,148,583, Rowe, Feb. 28, 1939; and 2,381,945, Field et al., Aug. 14, 1945.

Sealing Coaxial Electron Discharge Devices. Fig. 4. Patent No. 2,603,915. Filed Aug. 27, 1949. Issued July 22, 1952. One sheet of drawings. Assigned to Radio Corporation of America by John Lysak.

The figure shows a two-element vacuum tube forming a section A of a coaxial transmission line. The two elements are the outer conductor 10 and the cylindrical inner conductor 11. Glass rings 14 and 15 position the parts and these parts are of great importance. The patent claims the method of making this seal and discloses all the necessary steps.

The patent contains five claims and the references cited were 2,121,600, Knowles et al., June 21, 1938; 2,125,315, Ronci, Aug. 2, 1938; 2,174,375, Beggs, Sept. 26, 1939; 2,296,307, Power, Sept. 22, 1942; and 2,341,920, Hull, Feb. 15, 1944.

Tipping-off machine. Fig. 5. Patent No. 2,604,732. Filed May 5, 1951. Issued July 29, 1952. One sheet of drawings. Assigned to General Electric Company by Donald R. Bocast.

This machine is for fusing off and sealing the tubing by which electric lamps, radio tubes, etc., are exhausted and gas filled. The figure shows the exhaust tube 1 of a lamp 2 connected with the exhaust port 3 of an exhaust machine. Baffles, one of which is shown at 4, and burners 7 may be the same as in Patent No. 2,247,513 to Marshaus. A saddle 11 is mounted on a slide 14 and mechanism is provided to move the baffles 4 toward the lamp in an elevated position and then to lower them toward the lamp into the position shown. The burners soften a short portion of the exhaust tube and this is put under tension and gripped by the baffles 4. The burners 7 change direction as the sealing progresses, this being one of the features of the invention.

The patent discloses a modified form of the invention and contains six claims. No references were cited.

Lamp Sealing Machine. Fig. 6. Patent No. 2,605,590. Filed June 30, 1949. Issued Aug. 5, 1952. Four sheets of drawings. Assigned to Sylvania Electric Products, Inc., by C. A. Young and H. E. Baker.

This is a transfer apparatus for use in a machine for sealing mounts into the bulbs of electric lamps. The machine comprises an intermittently rotated turret 1 carrying a series of sealing heads 2 which receive mounts 7 from a conveyor 12. At the feeding station, the lamp bulb or tube 22 is moved down into contact with the flare of a mount. One feature of the invention resides in the means for accurately positioning the lead wires in the sealing heads. After the parts are placed in cor-

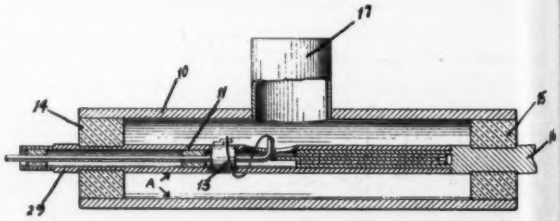


Fig. 4. Sealing Coaxial Electron Discharge Devices.

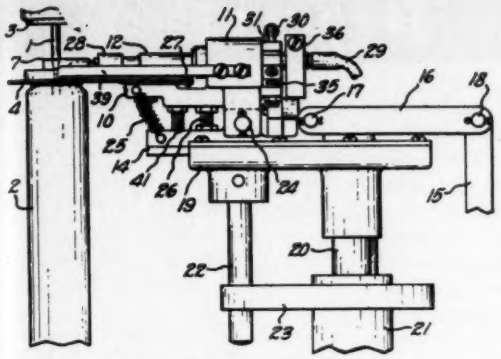


Fig. 5. Tipping-off Machine.

rect relation, the sealing operation may be performed in the usual manner. All necessary adjustments of the operating parts are provided for.

The patent contains three claims and the references cited were 734,734, McBerty, July 28, 1903; 1,593,825, Higgins, July 27, 1926; 1,813,565, Conn, July 7, 1931; and 1,947,610, McNamara, Feb. 20, 1934.

Fortified Cellular Glass. Patent No. 2,596,669. Filed Mar. 12, 1947. Issued May 13, 1952. No drawings. Assigned to Pittsburgh Corning Corporation, by Walter D. Ford.

This material is suited for use as thermal insulation particularly when subject to dampness. This process is stated in claim 3 as a process for manufacturing cellular glass having increased resistance to permeability by moisture at elevated temperatures, comprising the steps of providing an intimate mixture of finely pulverized glass, carbon and silica, in proportions by weigh of about 80% to 60% — 0.1% to 0.2% — and 20% to 40%, respectively, heating the mixture in closed molds to a temperature sufficient to effect the softening and cohering of the glass particles without substantial chemical reaction between glass, carbon or silica, increasing the temperature of the cohered mass sufficiently to generate cellulating gases through chemical reaction between the glass and

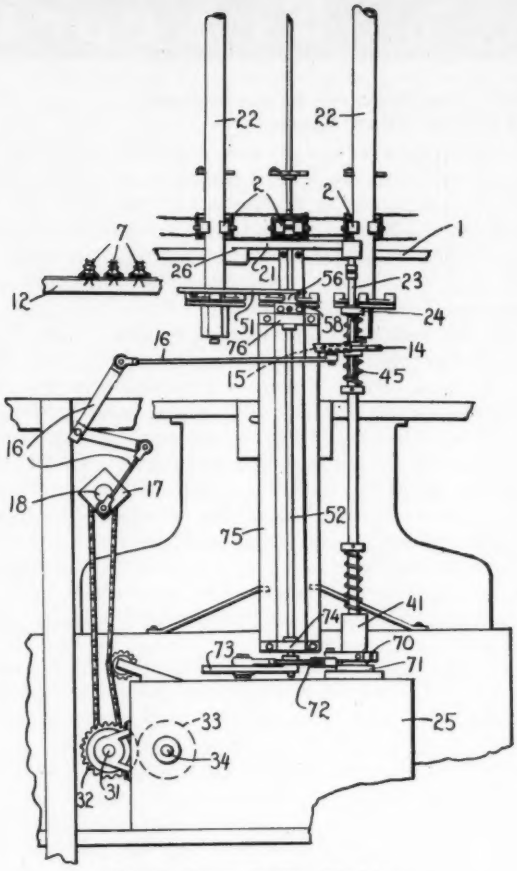


Fig. 6. Lamp Sealing Machine.

carbon without substantial reaction of the glass or carbon with the entrapped free silica.

The patent contains three process claims and the references cited were 2,123,536, Long, July 12, 1938; 2,233,608, Haux, Mar. 4, 1941; 2,310,432, Haux, Feb. 9, 1943; 2,337,672, Haux, Dec. 28, 1943; and 490,168, Great Britain, Aug. 10, 1938.

TIE-IN WINDOW DISPLAY PLANNED WITH AMERICAN GLASSWARE JUBILEE

The glassware window display idea, which aroused nation-wide interest because of its outstanding sales results in a test this Spring (THE GLASS INDUSTRY, July, page 374), has been made available to participants in the 1952 American Glassware Jubilee and will be an important feature of the nation-wide retail promotion.

The test display, based on the idea that a customer would buy more glassware if she could see it as it would appear on her own table or in her own kitchen, more than doubled sales on many of the items shown during the two-weeks test run at the S. H. Kress store on Fifth Avenue, New York City.

The display utilized blow-up glamour pictures of moderately-priced glassware in use. These pictures formed the background of the window. In the foreground the actual items were displayed, with price tags.

Blow-up pictures of this same type (nine of them in 16″x20″ size) are being furnished free of charge by member companies of the Glassware Institute of America for stores' use in building similar windows. Each picture features an item or items produced by one of the nine manufacturers represented. The pictures come in one package, along with a 14″x44″ banner bearing the Jubilee slogan, "Glassware for Gracious Living" in white script on a black background.

The Glassware Institute of America is also furnishing double-sided over-wire banners of red, white and blue, 11″x17″, in sets of three, as well as other merchandising aids. These include newspaper mats, radio scripts and spots, and localized newspaper stories. All are available upon request from the American Glassware Jubilee Committee, Room 1508, 247 Park Avenue, New York 17, N. Y. The Jubilee is scheduled for October 6 to 11.

• Armour Research Foundation of Illinois Institute of Technology will sponsor a Centennial Conference on Industrial Research on September 9, during the Centennial of Engineering.

Research Digest

Selenium Economy in the Making of "White Flint" Glasses

Since 1951 selenium has been just as short, and for the same reasons, in the United Kingdom as it has been in the United States. H. W. Howes (*Journal of the Society of Glass Technology*, June 1952), accordingly, has described the steps taken by his organization to decrease its usage in the glass container industry while still producing a "white flint" glass.

In approaching the problem of making "white flint" glass in an open tank furnace with a minimum of selenium, it is necessary first to consider quantities and sources of those impurities in the glass which make decolorizing necessary. First it is necessary to limit strictly the quantity of coloring elements in the glass. The two coloring elements usually and unavoidably present are iron and chromium. It has been found that Cr_2O_3 has a coloring power about twenty times as strong as Fe_2O_3. It is essential, therefore, to try to keep down the amount of chromium to a minimum (in the container glasses referred to, this figure is in the order of 0.0002%). The amount of chromium which can be tolerated in a white flint glass depends in part on the amount of iron present in the glass. Although weight for weight iron is less objectionable than chromium, in practice it is the main cause of poor color. The iron in the finished glass comes from the following three main sources: (1) the iron content of the raw materials, particularly the cullet; (2) the iron pick-up or contamination during transport, handling, storage, mixing and filling-ore of the raw materials; (3) the iron pick-up in the melting furnace.

To get a good colorless glass with the use of the minimum amount of selenium, all three sources of iron must be kept under constant control. The author attempts to keep the iron in his glasses between 0.044 and 0.057%, with 0.060% as the upper limit.

Of the raw materials, the most serious iron contamination occurs with sand, the largest single batch constituent. Any degree of iron contamination, therefore, has a proportionately high effect on the iron content of the glass. Wet sand is especially liable to contamination. In storage it is also sand that needs the most attention. Appreciable contamination can occur without being noticed by iron from structural steel inside buildings used for the storage of unpacked raw materials.

The addition of iron may result from the wear of shovels, grabs, elevator buckets and chains, mixers and the like. In one factory this iron pick-up was found to vary from 0.002 to 0.006% by weight of the finished glass.

Much iron is picked up during the melting process through the solution of refractories. In two recent measurements by actual analysis, the pick-up of iron in melting was equivalent to 0.011% of the glass in one furnace and to 0.015% in another.

Due to the pick-up during melting, factory cullet contains more iron than there is in the equivalent quantity of raw batch materials (including contamination). Handling, storage and crushing of factory cullet may increase still further its iron content.

The best foreign cullet, after thorough washing, magnetic separation and hand picking to remove nonmagnetic materials, will contain about 0.06% Fe_2O_3. Ten per cent of the usual washed foreign cullet will bring up the iron content of the glass by about 0.005%. It is apparent that if we ignore other factors and consider only glass color and conservation of selenium, the quality of the cullet should be carefully controlled and the quantity limited.

To get a consistently good colorless glass, all employees must be trained to be tidy and systematic. In present-day language, management must insist on good housekeeping. Factory cullet is sometimes overlooked in this respect. It must be kept clean. Apart from the effects of adventitious iron, dirty cullet may contain appreciable amounts of carbonaceous and other reducing materials which may prevent good decolorizing and lead to the waste of selenium. Aluminum caps are particularly undesirable, as they constitute a powerful reducing agent.

The purchase of good materials and the use of suitable precautions will give a glass having a minimum content of iron and chromium, which is the prerequisite to maximum economy in the use of selenium. To insure this maximum economy, other important matters must receive attention. Thus, the melting conditions, including the oxidizing effect of certain batch constituents, have an influence on the amount of selenium necessary to mask the color from any particular amount of iron.

In the case of arsenic, a small amount is desirable and sometimes even necessary, but an excess must be avoided. It is known that the use of a small quantity will by itself nearly decolorize a glass having a low iron content. That an excess was undesirable was proved by the fact that a reduction of the amount in the batch in some of the furnaces melting colorless glass permitted significant reductions in the amount of selenium necessary to give a good color. A reduction of 50% in arsenic permitted a reduction in selenium by up to 30%. In the author's best practice, about ½ lb. of arsenic and ⅛ oz. of selenium is used per ton of glass from batch.

To economize in selenium, it is desirable to have small amounts of oxidizing materials in the batch. Such materials provide a buffer against small variations of the furnace atmosphere. Small amounts of sodium nitrate in the batch will usually minimize the consumption of selenium. An excess of nitrate will increase the amount of selenium necessary, although to a lesser extent than will a corresponding excess of arsenic. Ten to 15 lbs. of niter per ton of glass from batch is about right, depending upon the method of firing the furnace and the type of fuel used.

Sodium and other sulphates, which aid melting, act as oxidizers. Unfortunately, these sulphates suppress the pink selenium color so that an excess of sulphate is undesirable. The average usage varies from about 9 to 15 lb./ton of glass from the batch.

Cobalt oxide is added in order to achieve the final decolorizing of the glass. It is evident that any material which adds a color to glass should be kept to a minimum in order to minimize absorption of light and so ensure

(*Continued on page* 484)

Current Statistical Position of Glass

Employment and payrolls: During June 1952 employment in the glass industry rose slightly and was reported at a preliminary 124,100. This represents a rise of .5 per cent from the 123,400 persons employed during May. Employment during June 1951 was 129,500, which is 4.1 per cent higher than June this year.

Payrolls during June also rose to a preliminary $36,191,816. Compared with May payrolls of $35,843,375, an increase of .9 per cent is shown. Payrolls during June 1951 were $40,952,825, which is 11.6 per cent above June 1952.

Glass container production, based on figures released by the Bureau of Census, was 10,042,384 gross for the month of July 1952. This is only a difference of .3 per cent from the previous month's 10,079,657 gross. During July 1951 production was 10,354,762 gross, or 3 per cent higher than July this year. At the close of the January-July 1952 period, production of glass containers has reached a total of 66,988,169 gross. Compared with the corresponding period in 1951, when production was 73,234,847 gross, 1952 production is running 8.5 per cent behind 1951.

Shipments of glass containers during July rose slightly to reach 9,938,018 gross. This is .8 per cent above the 9,850,465 gross shipped during June. Shipments during July 1951 were 9,686,865 gross, which is 2.5 per cent less than for July this year. Shipments at the close of the first seven months of 1952 have reached a total of 65,908,854 gross. At the close of the first seven months of 1951, shipments were 69,400,340 gross. Thus, 1952 shipments are running 5 per cent behind 1951.

Stocks on hand at the close of July 1952 were 10,106,700 gross. This is only slightly higher than the 10,060,049 gross on hand at the end of June 1952 and 2.5 per cent below the 10,375,274 gross on hand at the end of July 1951.

Automatic tumbler production during June 1952 rose 6.4 per cent to reach 4,830,500 dozens. During May, production had been 4,536,844. During June 1951, 6,383,874 dozens were produced. Shipments also increased during June 1952 and were 5,490,876 dozens. This is 3 per cent above the 5,329,111 dozens shipped during May. Shipments during June 1951 were 5,736,905 dozens. Stocks on hand at the close of June 1952 were 8,349,353 dozens. This is a drop of 15.5 per cent from the previous month's stocks of 9,892,475 dozens. At the close of June 1951, stocks on hand were 11,973,689 dozens.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware during June 1952 dropped 18.1 per cent from the previous month's 3,551,320 dozens to reach 2,907,521 dozens. Sales during June 1951 were 2,682,232 dozens. At the close of the 12-month period ending June 1952, manufacturers' sales have reached a total of 38,775,475 dozens. This is 4.2 per cent below the 40,491,694 dozens sold during the 12-month period ending June 1951.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers	July 1952
Foods	891,678
Medicinal & Health Supplies	964,765
Chemicals, Household & Industrial	674,202
Beverages, Returnable	1,020,206
Beverages, Non-returnable	53,278
Beer, Returnable	265,314
Beer, Non-returnable	978,996
Liquors	654,660
Wines	250,605
Toiletries & Cosmetics	506,017
Sub-total (Narrow)	6,259,721
Wide Mouth Containers	
Foods	*2,583,351
Dairy Products	264,467
Medicinal & Health Supplies	241,768
Chemicals, Household & Industrial	114,176
Toiletries & Cosmetics	121,538
Packers' Tumblers	149,951
Sub-total (Wide)	3,475,251
Total Domestic	9,734,972
Export Shipments	203,046
TOTAL SHIPMENTS	9,938,018

* This figure includes Home Canning.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production July 1952	Stocks July 1952
Foods; Medicinal & Health Supplies; Chemicals, Household & Industrial; Toiletries and Cosmetics	Narrow Neck	3,172,406	3,974,897
	Wide Mouth	*3,197,965	*3,196,690
Dairy Products		258,028	290,934
Beverages, Returnable		1,024,200	635,398
Beverages, Non-returnable		51,232	40,493
Beer, Returnable		292,521	297,932
Beer, Non-returnable		975,734	487,343
Liquors		684,136	769,719
Wines		232,879	279,118
Packers' Tumblers		153,283	134,176
TOTAL		10,042,384	10,106,700

* This figure includes Home Canning.

NATIONAL SAFETY COUNCIL PUBLISHES ACCIDENT STATISTICS

You could work five days a week for the next million years and not make up the time lost as a result of 1951's work accidents. The 280,000 man-days of lost labor represent only one aspect of the economic loss from work accidents, according to "Accident Facts," the National Safety Council's statistical annual.

Twenty-one pages of the 96-page book are devoted exclusively to occupational accidents and provide the factual background necessary to give an industrial safety program direction. Commonest sources of injury, part of the body most frequently injured, off-the-job problems, women in industry and many other subjects are included.

New Equipment and Supplies

"FIBERFRAX"—A NEW INDUSTRIAL FIBER

The Carborundum Company, Niagara Falls, New York, has announced a new manmade fiber showing promise in industrial and defense applications. The new material, trademarked "Fiberfrax," resists temperatures that melt cast iron, yet it can be used as a superfilter or as a base for entirely new types of insulation, and fireproof and electrical papers.

The new fiber, according to Carborundum President Clinton F. Robinson, is the latest product of the continuing research at The Carborundum Company. The firm manufactures silicon carbide and aluminum oxide, which it then processes into bonded and coated abrasives, super refractories, electric heating elements and electric resistors. "Fiberfrax" fiber is a kindred product: its raw materials are aluminum oxide and sand, its manufacture involves the same type of electric-furnace melting that produces aluminum oxide abrasives. No critical materials, such as platinum, are required in the production equipment.

The combination of properties of "Fiberfrax" fiber opens up a wide range of industrial and defense use. At the present time it is finding applications as high-temperatured insulation in combination and exhaust systems of jet engines; it is under study by the Office of Naval Research for use in highly specialized papers; it can replace or be combined with critical asbestos in many electrical and thermal uses; it can be bonded into insulating panels that will not only resist fire and prevent heat loss, but will also deaden sound. As a filter, "Fiberfrax" fiber can improve the efficiency of gas and fume filtration.

Its inertness makes possible cleaning and reuse of the material without loss of filtering efficiency. Studies of potential use indicate that the material may be suitable for heavy-duty brake linings, as the strength-supplying component in formed plastic laminates like radomes and body armor, in high-temperature gasketing, for vibration dampening and as a flame filter to remove ash in gas turbines. In many applications, its light weight—the fiber as manufactured weighs only two lb. per cubic foot—will prove especially advantageous.

Pilot production equipment at Carborundum can produce the material at the rate of 30 tons a month. It is so new that exhaustive properties tests have not been completed and are still under way. Its unusual characteristics in some cases have made it necessary for technologists to devise special testing procedures, since "Fiberfrax" fiber doesn't always fit into test methods developed for less versatile materials.

It is adaptable to the refractory markets because its high heat resistance, light weight and low heat transmission make it competitive with insulating refractories for industrial furnace insulation. But its attendant properties—filtration efficiency, electrical characteristics, sound-deadening ability—will, according to Harry C. Martin, Director of Research, make it desirable for use in the chemical, electrical, aviation and papermaking fields.

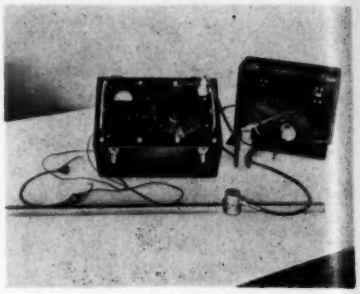
The fiber is made by melting aluminum oxide and sand in an electric furnace, then subjecting a stream of the molten lava-like material to a controlled blast of air. The molten material is blown into a fluffy mass made up of random arrangements of extremely fine fibers. The fibers range up to three inches in length and have an average thickness of about one twenty-fifth that of a human hair, about one-fourth that of fine silk. Although it is produced and collected in a fluffy mass, "Fiberfrax" fiber eventually will be processed into felted blankets, firmly bonded batts, tape and paperlike forms.

The raw materials from which the fiber is made and the type of fiber produced account for its unusual properties. Melting of the alumina and silica is done at 3300°F. The fiber easily withstands 2300°F. without loss of properties and does not soften at temperatures approaching 3000°F. "Fiberfrax" fiber's inert raw materials provide corrosion resistance, electrical properties and low thermal conductivity. The fitnesses of the fibers and their random arrangement produce the efficient filtering abilities of the material, and also account for the fact that it has pronounced capillary characteristics that allow it to lift liquids without absorbing them.

Basically, the product is a vitreous ceramic, rather than crystalline. The relatively rapid cooling from the melt provides the fibers with a smooth vitreous surface and long length and may account for their resilience. At the present state of progress, the fiber is not available in spun, woven or filament form, but mixtures with other fibers permit carding and spinning.

At the present time, an extensive program of tests is now underway by Carborundum. Samples of the material are also out on product test with a number of manufacturers. In the meantime, Carborundum is proceeding with a $500,000 plant expansion program to make "Fiberfrax" fiber in greater quantities and thus reduce unit cost. "Fiberfrax" fiber will be marketed by the Refractories Division of the company, with headquarters in Perth Amboy, New Jersey, under the supervision of Clarence E. Hawke, Vice President in charge of the Refractories Division.

In addition to this new product research on "Fiberfrax" fiber, the firm has a subsidiary company, Carborundum Metals, engaged in developing a process of producing zirconium metal from zirconium silicate.



ULTRASONIC MICROMETER

Branson Instruments, Inc., 430 Fairfield Avenue, Stamford, Conn., has announced the development of a new "Audigage" ultrasonic micrometer for making ultrasonic thickness measurements.

Measurements consistently within ½ of 1 per cent of actual thickness have been obtained from one side of materials with smooth surfaces. The micrometer can be used on homogeneous materials such as glass, aluminum, copper, steel and other dense substances capable of transmitting the ultrasonic waves generated by a vibrating crystal. The ultrasonic micrometer measures thickness by determining the frequency at which resonance of the high-frequency sound waves occurs in the material under test. Resonance is indicated by maximum deflection of a meter and maximum strength of a tone audible in the headphones.

Since accuracy, rather than rough checking, is the primary objective of this micrometer, it is designed to operate with high precision over an infinite series of relatively narrow thickness ranges between 0.010" and 12". Plugs in frequency coils and matched dials for any desired frequency, both of which are readily interchangeable without dissassembly of the instrument, permit the selection of the one specific frequency best suited to the required thickness-range. Since the instrument accommodates two coils at once and each dial has provision for two scales, the user has two thickness-ranges at his command at all times by simply turning the Range-Selector Control. Scales can be computed either for direct reading or to show deviations from any standard thickness desired.

The illustration above shows the Ultrasonic Micrometer in use for checking the uniformity of internal dimensions of a rectangular tube; wall thickness is determined ultrasonically and then subtracted from the known outside dimensions. A special jig holds the crystal as it is slid along the tube. Other uses include high-precision thickness gauging of manufactured parts, eccentricity measurements on tubular products, precise determination of corrosion rates in pilot plants and in early stages of full-scale operations, etc.

AIR-COOLED FLAME RECTIFIER HEAD

Minneapolis - Honeywell Regulator Company, Industrial Division, Philadelphia 44, Pa., has developed an air-cooled flame rectifier head for use on applications where temperatures around furnace walls are more than 1300°F. A companion device, a chuck adapter, has been designed for changing any Honeywell insulator-type flame head to a right angle electrode holder.

The rectifier head is also for use when a positive pressure inside a burner tends to force out heat around head and chuck. The basic unit consists of the head, an air-tight electrical connector, an eight-inch stainless steel rod and chuck assembly, and an outside pipe support and insulator.

When in use, the new chuck adapter is connected to the flame head at one end, and the opposite end is drilled for a 3/16-inch diameter rod that will run at right angles. The arrangement permits the electrode to be mounted at various distances from the flame head, resulting in greater accessibility to a flame by the electrode, but without damage to the head.

CHROME CARBIDE TEST KIT

General Electric Company, Carboloy Department, 11177 East 8 Mile Road, Detroit 32, Michigan, has made available a sample test kit containing a variety of shapes and sizes of the new Grade 608 cemented chrome carbide.

Grade 608 chromium carbide has shown extremely high resistance to acids, salt spray, steam erosion and high temperature oxidation, combined with good abrasion resistance. Typical applications include shear blades for molten glass, core pins for baking ceramic parts, nozzles and valves for processing chemicals, fats, oils, soaps, etc., etc.

The kit contains three ¼-inch square bars 2 inches long; two ¼-inch square bars 1 inch long; three ½-inch OD 5/16-inch long bushings with a 5/16-inch ID and one ⅛-inch diameter rod 1 inch long.

NEW PORTABLE OVEN

Grieve-Hendry Company, Inc., Chicago 22, Illinois, has announced a new portable electric oven for high temperature processing, called Model HT-2. The new oven features a thermostat control with temperature range of 300° to 1000°F. and a stainless steel interior.

Two or more of these ovens can be used in a group or bank as they are so constructed to nest one on the other. Individual ovens in a group may be cut out or ovens can be operated at different temperatures. Construction is heavy gauge steel with a minimum of 4″ of fiber glass insulation. Double doors are provided for sealing in heat. Drip pan, lower shelf, pilot light and outside reading thermometer are standard equipment.

MOTORIZED TURNTABLE

Eisler Engineering Company, Inc., 750 South 13th Street, Newark 3, N. J., has placed on the market a motorized turntable for use in production work. This turntable can be supplied with from 6 to 48 positions, and can be used for many purposes in various production lines where the requirements are for turning the work spindle, rotating the spindle, and starting and stopping at various positions where various operations can be placed on the particular spindle in accordance with the requirements.

In the glass industry the turntable can be used for lamps, electronic tubes, electronic parts, glass bottles, bead making on leadwires, vials, etc.; in use for glazing, sealing, cracking-off, mounting, spraying, etc.

The index speed can be adjusted with the combination of the timer and adjustable speed pulley from a few seconds to several minute intervals. An additional foot switch can control the index time for any desired length of operating period. The work spindles are either rotating or stationary.

The machine has well constructed table and legs. Above the table the turret, with the operating positions, is placed. Underneath are located all driving parts, geneva index mechanism, speed reducer, motor with adjustable speed pulley and solenoid operated clutch. In front and side of the machine, the electrical equipment, the motor starter, relay, timer and foot switch are conveniently located.

CATALOGS RECEIVED

M. H. Detrick Company, 111 West Washington Street, Chicago, Illinois, has issued a new booklet on the subject of how to enclose heat, outlining the development of the "Art of Enclosing Heat." Under such headings as "Origin of the Arch," "Flat Suspended Arch," "Sectionally Supported Walls," the important steps in evolving the present designs are covered.

The center section shows how the knowledge gained from nearly half a century of experience is applied to specific heat enclosure problems in various industries. Boilers, oil stills, steel heating units, open hearths and many other special heating units are discussed. Graphs and tables are presented which help to select the proper type of construction for any combination of heat and operating conditions.

The third section describes a variety of modern heat enclosure constructions which may be applied to present-day units, as well as many units still to be developed.

Stauffer Chemical Company, 420 Lexington Avenue, New York 17, N. Y.. has published a revised 112-page edition of its general catalog covering basic chemicals for industry and agriculture.

As in the earlier editions, considerable data are given on all products, and numerous tables on specific gravity, viscosity, specific heat, solubility and other properties give valuable assistance to the user of Stauffer chemicals.

Barber-Greene Company, Aurora, Illinois, has just issued an 8-page, two-color bulletin describing its conveyor belts. Summing up the engineering and precision manufacturing behind every Barber-Greene belt, the bulletin makes a thorough analysis of it, showing how its construction is designed to defeat the major causes of belt failure.

Pictured and discussed are these major causes of belt failure: ply separation, carcass deterioration, irregular plies, edge wear and longitudinal seam failure. Belt selection tables are in two major sections, simplifying a once complicated process. Representative types of belt protective equipment made by the firm are also briefly treated in the bulletin.

Selas Corporation of America, Philadelphia 34, Pa., has issued a new bulletin describing a special design of a tunnel-type multiport gas burner unit that can be used in either furnace or open-firing applications.

These burners are designed to operate with pressurized mixtures of any fuel gas an air. The design provides for operation on either low or high gas-air mixture pressures. Burners of this type can deliver from 2,000 to 6,000,000 BTU per hour. Bulletin SC-1009, "Selas Refrak Screen Burners," describes this equipment.

North American Philips Company, Research and Control Instruments Division, 750 South Fulton Avenue, Mount Vernon, New York, has made available a new 4-page folder entitled "X-Ray Techniques Can Help You Solve Your Materials Problems."

The folder contains a technical article from a national trade publication that describes X-Ray spectometry with automatic chart recording as an important tool for solving today's material problems.

Illustrated with drawings, charts and photos, the folder clearly and concisely presents to the reader all important details concerning operating principles and uses of this X-Ray technique.

"PLANT HOUSEKEEPING" SUBJECT IN SAFETY NEWS LETTER

In the current issue of the Safety News Letter issued by the Glass and Ceramics Section of the National Safety Council, Harry McDonald, Plant Manager of the Armstrong Cork Company's Dunkirk, Indiana, plant is the author of a brief report in which he discusses the subject, "Plant Housekeeping." Mr. McDonald states: Housekeeping in a manufacturing plant presents the same problems as in a home. In the first place, the cleanliness in the home isn't going to be any better than the family wants it. It can be kept clean on an hourly basis or the dirt can accumulate until, to keep from being buried, it is necessary to take a shovel and broom and dig your way out.

The good housekeeper usually follows a combination of the two methods. He or she keeps hourly accumulations in an orderly condition, and then upon occasion has a genuine "house cleaning" to get rid of the slower accumulating dirt. Good housekeeping not only means getting rid of dirt and debris, but it also means keeping articles in an orderly arrangement and "a place for everything and everything in its place." Even junk doesn't look too bad if it is piled in an orderly manner instead of like jack straws.

But unless she works herself to death or uses a good club, Mother can't keep a clean and orderly house if the old man and the kids continually keep it cluttered up with cigar and cigarette butts and ashes; clothes thrown around every which way; magazines and newspapers scattered in profusion and confusion all over the premises.

The same thing is true of a manufacturing plant. With the best intentions in the world, management must have the cooperation of each and every employee if the surroundings are to be clean and our work places pleasant places in which to work. Otherwise, unless we double our working force, and have a broom and shovel man for each employee, we can't have our working places as clean and pleasant as they should be.

I can remember the famous "Full Dinner Pail" era. I haven't seen a dinner-pail for so long I would probably think it was a tool kit or a fishing tackle box. I think the present time will go down in history as the "Paper Bag and Waxed Paper" era. I have no fault with paper bag lunch kits or waxed paper sandwich wrappers. They are very handy. The bags eliminate washing and the waxpaper preserves food. But after being used, their place is in the rubbish can and not scattered around in and on the premises.

It seems that every plant has certain types of employees.

There's the "Basketball" type. This particular animal seems to thrive especially in Indiana where we all think we're God's gift to basketball. When through with a piece of paper, this type never walks over and puts it in the rubbish can. No, sir. He must have his "shot at the basket." The thing that he overlooks is that a good basketball player always follows in on his shot. But not this cookie. If he misses the rubbish can, "To hell with it."

Then we have the "Wader," also known as the "Cruncher." He is most apt to be found in the forming department. He just loves to wade his crunching way through an accumulation of broken glass on the floor. It would take him all of fifteen seconds to sweep it into a neat pile for the floor boy to shovel into the wheelbarrow as he makes his rounds. But that would mean a reasonably clean, neat working place, and the "Wader" is allergic to neatness.

Another species is the "Bottle and Tumbler" dropper. He loves to scatter empty coke bottles and empty tumblers containing the remains of stale coffee all over the premises. The cullet barrel or empty coke box is only 50-feet away, but, after all, "Doesn't an area nicely decorated with these dead soldiers look just ducky? And besides a lost Coca-Cola bottle only costs the Welfare Fund 2¢!"

There is the "Flipper" who just loves to flip a cigarette butt even though the sand bucket between the lehrs is only 2-feet away.

Let's not forget the "Squirter." His favorite color is tobacco brown. His favorite place is corners. How he loves to squirt a bountiful supply of tobacco juice preferably against a white wall or a clean spot on the floor. His tobacco cuds are strewn around the premises until it appears as though a horse-drawn circus parade had passed through the department.

And the "Draper." Undoubtedly this bird is a frustrated interior decorator. He dearly loves to reach into the wiping rag container for a rag, preferably digging in as deep as possible so that as he comes out with the rag, he can drag out several more and strew them all along the floor. It just would never occur to him to put the excess back. After using the rag, he really has a field day. It can be then festooned in a very graceful manner over any pipe, conduit, bench or locker; just given a scatter rug effect over the floor; or thrown just outside the door. Put it in the container provided for dirty wiping rags? Don't be silly!

A very distinguished member of this "Draper" family is the maintenance man whose trail through the plant is plainly marked by the left-overs of a job—light bulb wrappers, old electric wiring, pipe ends, scaffolding, bolts, nuts and what-have-you. The mystery as to why this party feels he has a right to mess up a department with his scrap has never been solved.

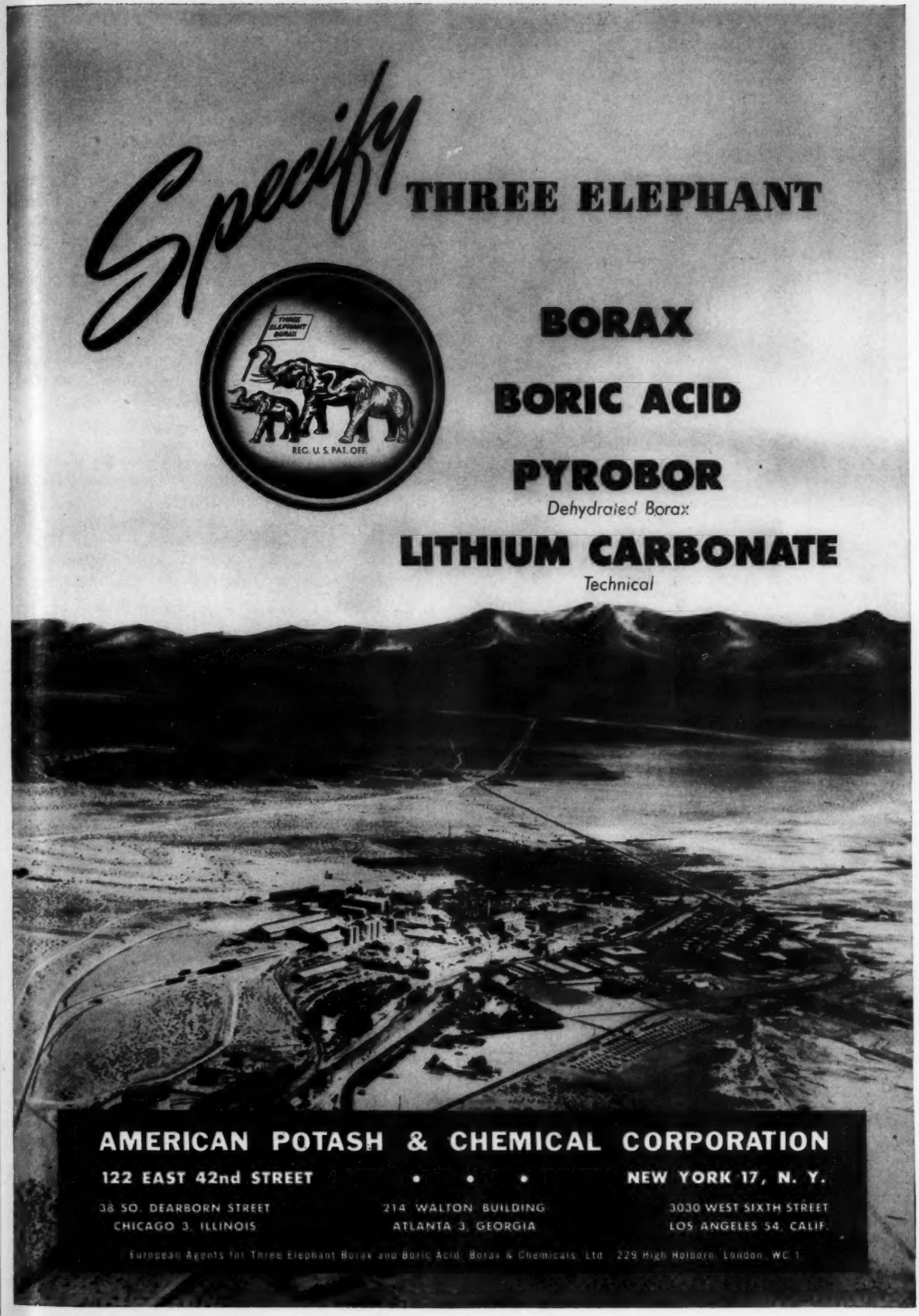
THATCHER MAKES APPOINTMENTS

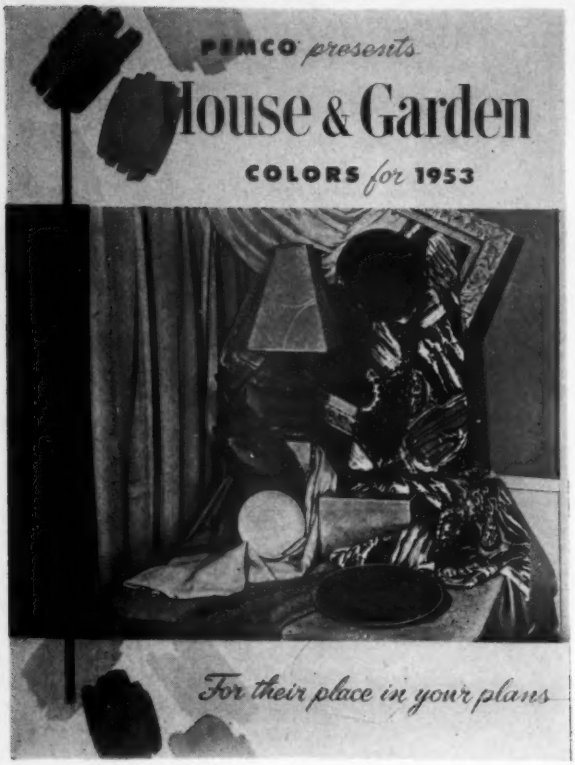
William R. Rifenburgh has just been appointed Consumer Products and Export Sales Manager of the McKee Glass Division of Thatcher Glass Manufacturing Company, Inc., according to an announcement by W. A. Wood, Vice President and General Sales Manager of the Division.

Mr. Rifenburgh has been associated with the company since March of this year in the Consumer Products Division. Prior to that he represented the Bonny Distributing Company for six years covering the Southern Tier of New York State.

Mr. Wood also announced that C. E. Brown has been appointed a full-time direct salesman for New York State and will work out of the parent company's office at Rochester.

Mr. Brown's appointment is in line with the McKee Division's new policy of direct selling in some areas, rather than exclusively through manufacturers' representatives. Mr. Brown was previously specialty salesman for the Hazel-Atlas Glass Company for 3½ years, also covering New York State.


Specify
THREE ELEPHANT
THREE ELEPHANT BORAX
REG. U. S. PAT. OFF.
BORAX
BORIC ACID
PYROBOR
Dehydrated Borax
LITHIUM CARBONATE
Technical
AMERICAN POTASH & CHEMICAL CORPORATION
122 EAST 42nd STREET • • • NEW YORK 17, N. Y.
38 SO. DEARBORN STREET
CHICAGO 3, ILLINOIS
214 WALTON BUILDING
ATLANTA 3, GEORGIA
3030 WEST SIXTH STREET
LOS ANGELES 54, CALIF.
European Agents for Three Elephant Borax and Boric Acid: Borax & Chemicals Ltd., 229 High Holborn, London, WC 1



PEMCO CORPORATION PRESENTS HOUSE GARDEN COLORS

House & Garden colors for 1953 are being made available to the glass and ceramic industries by Pemco Corporation. The announcement is being made in an 8″x11″ full-color broadside, lithographed front and back (see cut).

The announcement points out that "House & Garden colors for 1953 were selected by the editors of *House & Garden* working with the nation's top decorators and designers of dinnerware, decorative accessories, lamps, fabrics, floor coverings, household equipment, home furnishings and miscellaneous products."

The Pemco color laboratory explored the entire field of underglazes, overglazes and glaze stains and succeeded in matching most of the House & Garden colors for 1953 in line with good ceramic technology. Pemco has actually produced these colors in its own laboratory, the announcement states, and is prepared to offer its services in reproducing them in the individual manufacturer's own glazes to suit his specific requirements.

DIFFRACTION SCHOOL TO BE HELD DURING OCTOBER

The fall session of the semi-annual X-ray diffraction school will be held at the plant of North American Philips Company, Inc., 750 South Fulton Avenue, Mount Vernon, New York, during the week beginning Monday, October 6, and extending through October 10. Registration for the school will be limited to 125 for the first four days and to 150 on Friday, the day devoted to actual application problems when guest speakers discuss details on methods currently in use around industrial laboratories and plants.

NATIONAL SAFETY CONGRESS TO BE HELD IN CHICAGO

Key safety men from the glass and ceramic industries will be among the more than 12,000 accident prevention specialists who will meet in Chicago for the 40th National Safety Congress and Exposition, October 20 through 24.

Two programs will be devoted exclusively to the special hazards involved in the manufacture of glass and ceramic products. The session on Monday afternoon will feature a motion picture on "Grinding Wheel Safety." The movie will be followed by Joseph A. Houghton, Industrial Hygienist, Liberty Mutual Insurance Company, speaking on chemical hazards in the glass and ceramic industries.

On Tuesday afternoon, Clyde R. Powell, Public Relations Director, Lehigh Safety Shoe Company, will use magic to highlight his talk, "Don't Bet Your Life." The session will close with a film in industrial exhaust ventilation and a round-table discussion on ventilation problems in the glass and ceramic industries.

As in previous years, the American Society of Safety Engineers will present morning sessions on topics of general interest. Subjects include electrical hazards, suggestion systems, safety meetings for supervisors, making pictures for safety, community safety programs and practical methods for influencing people for safety.

HAZEL-ATLAS TO BUILD NEW GLASS CONTAINER PLANT

J. H. McNash, President of Hazel-Atlas Glass Company, has announced the purchase of a 75-acre tract of land located in the Chicago area as a site for the construction of a new plant for the manufacture of glass containers.

Present plans contemplate the beginning of construction at an early date. The availability of structural materials, particularly steel, will likely determine the time for completion.

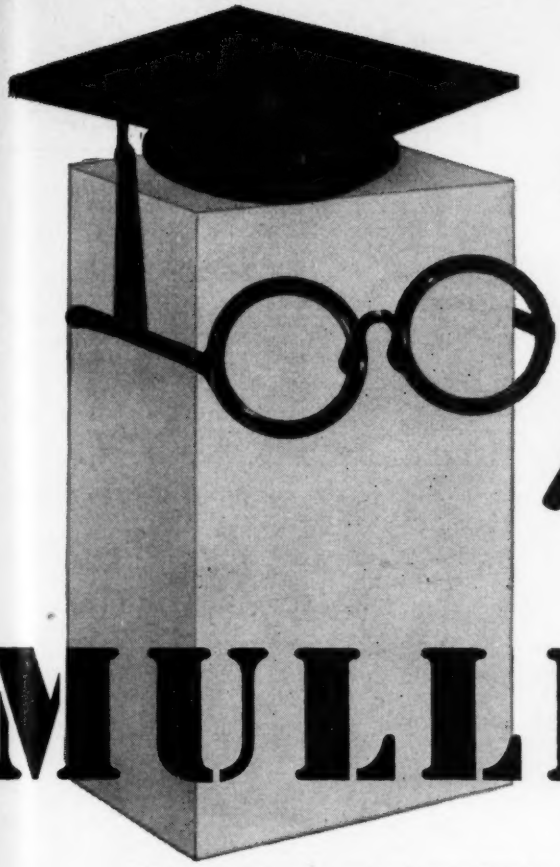
The new plant at Plainfield, Illinois, will be the fifteenth plant owned and operated by the company. Headquarters are at Wheeling, West Virginia.

JOHN CROWTHER NAMED ASSISTANT SALES MANAGER OF STAUFFER

T. A. Haschke, Sales Manager of Stauffer Chemical Company, has announced the appointment of John Crowther to the position of Assistant Sales Manager.

Mr. Crowther has been associated with Stauffer Chemical Company for seven years and was Director of Eastern Division Research, the main offices of which are at Chauncey, New York. Mr. Crowther is a well-known chemical engineer and is a member of the American Institute of Chemical Engineers, Commercial Chemical Development Association and Chemists' Club.

Before joining Stauffer, Mr. Crowther was a Major in the U. S. Air Force in Europe. Prior to the war, he was with the M. W. Kellogg Company.



Always the RIGHT ANSWER...

To The Need For Lower Cost Per Ton of Glass Melted

MULLIFLUX

Wherever glass is melted, new Walsh Mulliflux "S" and Mulliflux "B", for sidewalls and bottoms of glass furnaces, respectively, is in a class by itself.

Walsh Mulliflux sets new standards for long life and dependability, the result of expert vacuum casting and the right balance of desirable properties that offer maximum resistance to destructive elements encountered in modern glass melting practice.

Better research and ceramic engineering, reponsible for the development of Mulliflux and other Walsh Refractories for the glass industry, are at your disposal in helping you to solve your furnace problems. For additional information write, wire or phone.

The Answer To Today's Demand For Greater Tonnages At Lower Cost

Identify Walsh Mulliflux by these distinctive markings

WALSH REFRACTORIES CAST MULLIFLUX B CORP. ST. LOUIS, MO.

. . . for Bottoms

WALSH REFRACTORIES CAST MULLIFLUX S CORP. ST. LOUIS, MO.

. . . for Sidewalls

OTHER WALSH PRODUCTS:

Cast-Flux, Vacuum Cast Tank Blocks; CSR, Cast Sillimanite Refractory; Debiteuse; Refractory, Upper Structure Grade; Floaters; Channels; Feeder Parts; Pot Furnace Refractories; Prepared Clays; Fire Brick and High Temperature Cements.

FOR OVER 50 YEARS

WALSH
REFRACTORIES CORPORATION
ST. LOUIS, MISSOURI, U.S.A.

MANUFACTURERS OF HIGH GRADE REFRACTORIES

101 FERRY ST., ST. LOUIS 7, MO.
FACTORIES: ST. LOUIS, MO. AND VANDALIA, MO.

THERMAL EXPANSION OF GLASSES . . . *(Continued from page 465)*

System No.	System	Investigator	Weight Per Cent	Composition			Coefficient of Expansion ($\alpha \times 10^7$)	Temperature Range (°C.)
27 (Continued)				Na_2O	ZrO_2	SiO_2		
			0.75	21.75	15.15	61.10	91.0	
			1.0	21.09	20.59	56.38	85.9	
				18.74	5.80	75.00	87.1	
				18.42	11.73	69.32	80.1	
				18.78	14.80	65.08	84.5	
28	Na_2O-PbO-SiO_2	S. English, W. E. S. Turner & F. Winks, J. Soc. Glass Tech., *11*,300T (1927)	(2-x) Na_2OxPbO6SiO_2	Na_2O	PbO	SiO_2		
			x = 0.1	*22.62	3.75	72.86	109.0	25-90
			0.2	20.49	7.89	70.97	104.1	
			0.3	18.65	12.56	67.78	99.7	
			0.4	17.73	15.70	65.84	96.4	
			0.5	15.55	19.11	64.55	92.8	
			0.6	15.35	22.31	62.44	90.3	
			0.7	14.00	24.46	60.88	87.0	
			0.8	12.31	27.77	59.34	84.2	
		J. Mori, J. Japan Cer. Assoc., *368*.176 (1923) Cer. Abs., 2,245 (1923)	(2-x) Na_2OxPbO6SiO_2					
			x = 0.5	*16.34	16.35	65.95	96.6	30-100
			0.6	14.06	22.94	61.67	92.9	
			0.7	13.83	24.33	60.30	93.4	
			0.8	12.40	28.01	58.52	90.3	
			0.9	11.35	31.57	55.87	88.0	
			1.0	10.02	33.96	54.84	84.4	
			1.1	8.27	36.60	54.10	78.1	
			1.2	7.88	37.45	53.58	76.1	
			1.3	6.90	39.24	52.61	72.9	
			1.4	5.61	41.83	51.21	70.5	
			1.5	4.61	44.76	49.82	66.6	
29	MgO-Al_2O_3-SiO_2	H. W. Reid & F. A. Hummel J. Amer. Cer. Soc., *34*,319 (1951)	MgOAl_2O_3xSiO_2	MgO	Al_2O_3	SiO_2		
			x = 4	10.54	26.65	62.81	33.1	25-600
			6	8.02	20.28	71.7	27.1	
			10	5.42	13.72	80.86	20.2	
				25.0	21.0	54.0	51.3	
				20.3	18.3	61.4	43.1	
30	Al_2O_3-B_2O_3-SiO_2	A. E. Dale & J. E. Stanworth J. Soc. Glass Tech., *29*,77T (1945)		Al_2O_3	B_2O_3	SiO_2		
				4.0	12.5	83.5	13.0	0-400
				4.0	17.5	78.5	18.0	
31	TiO_2-Al_2O_3-SiO_2	A. E. Badger & I. M. Doney Glass Ind., *21*,309 (1940)		Authors claim to have investigated the systems but give no data.				
32	ZrO_2-Al_2O_3-SiO_2							
33	Na_2O-CaO-GeO_2	N. M. Parikh, "Physical Properties of Na_2O-CaO-GeO_2 Glasses", M.S. Thesis, New York State College of Ceramics, June 1950		Na_2O	CaO	GeO_2		
				14.1	6.5	79.4	82.4	
				15.4	5.35	79.35	85.8	
				16.6	4.28	79.3	89.8	
				17.75	3.22	79.2	94.1	
				18.9	2.15	79.0	99.0	

(To Be Continued)

LITHIUM COMPOUNDS MEETING

The expansion goal of 10 million pounds of lithium carbonate equivalents by 1955 is a very conservative goal, the Lithium Compounds Industry Advisory Committee stated at its meeting with officials of the National Production Authority.

Government officials presented a breakdown of estimated requirements for military needs, welding and brazing (primarily for aluminum), greases and ceramics, which were discussed in relation to the yearly capacity, production and estimated requirements for lithium compounds for the 1950-1955 period.

After reviewing the estimates of supply and requirements, the committee discussed whether Government action or controls would be necessary to cope with the developing shortage over the next 18 months before new capacity comes into production. It has been estimated that deficits will occur between production and requirements of 1,500,000 pounds in 1952 and of 3,500,000 pounds in 1953. Three members of the committee recommended that the present system of directives on the producers be continued. The other member favored an allocation program.

The committee asked that consideration be given to equalizing the defense load on the individual producers and to setting a ceiling on the mandatory acceptance of DO ratings. Industry members said they would submit data on the DO loan for the past six months broken down by months and by individual lithium salts.

WORKING MODEL OF PILKINGTON MACHINE ON DISPLAY

Visitors to the Canadian National Exhibition, which was opened from August 22 to September 6, were able to see the working model of the machine at St. Helens, England, which produces the Pilkington plate glass made by the Twin process.

The Twin process, which was developed by the Pilkingtons, is one whereby both sides of a moving ribbon of glass are ground and polished simultaneously and is the very latest development in plate glass manufacture.

• Most often, it takes many factors to solve color problems. Like time. Like actual experience in all kinds of ware processing techniques, in large plants and small. Like laboratories with every modern facility for analytical and creative research . . . a library of case histories dating back many years . . . a staff of technologists devoted entirely to finding ways to reduce rejects, improve quality and increase ware production for ceramic and glass manufacturers.

Drakenfeld has all these qualifications to save you time and effort, to find solutions to *your* color problems . . . plus color manufacturing facilities and rigid controls that assure colors formulated to your particular decorating methods and standards.

Whatever you need—in colors . . . in chemicals . . . in supplies . . . in counsel on decorating plant layout or decorating procedures — Drakenfeld cooperation can help you achieve greater efficiency and increased profits. Your inquiry is invited.

CALL ON **Drakenfeld** ***R PARTNER IN SOLVING COLOR PROBLEMS***

B. F. Drakenfeld & Co., Inc. **45-47 Park Place, New York 7, N. Y.**

Factory and Laboratories: Washington, Pa.
Pacific Coast Agents: Braun Corp., Los Angeles 21 • Braun-Knecht-Heimann Co., San Francisco 19

DEPENDABLE SERVICE ON: Acid, Alkali and Sulphide Resistant Glass Colors and Enamels . . . Crystal Ices . . . Squeegee and Printing Oils . . . Spraying and Banding Mediums . . . Glassmakers' Chemicals . . . Glass Decolorizers . . . Glass Frosting Compounds . . . Decorating Supplies.

SURFACE TENSION OF GLASSES . . .

(*Continued from page* 457)

Ferguson[31] gives the formula

$$a^2 = q^2 - 0.606a^3/r$$

where:

$a^2 = 2\gamma/g\rho$.
r = widest radius in a horizontal plane.
q = height above plane of r.

It is evident that this formula is restricted to drops whose contact angle is greater than 90°, measured through the liquid, since the widest diameter must be taken where the sides of the drop are vertical. Ferguson[31] also gives a formula which does not contain this restriction.

$$\gamma = \frac{g\rho}{x_1}\left\{\frac{2Cx^2_1 + AB - Ax^2_1y_1}{2A\sin\Theta + 2x^2_1\cos\Theta - x_1s}\right\} \qquad (27)$$

where:

$C = \int_0^{y_1} xydy$
$B = \int_0^{y_1} x^2dy$
$A = \int_0^{y_1} 2xdy$
s = distance LOM
Θ = contact angle

A table is made of x, y, xy and x^2 for several points along the outline of the drop, illustrated in Fig. 4 (measurements are possible from a photograph if the scale of enlargement is known). The values of A, B and C may be obtained by numerical integration. This, however, is a cumbersome process.

The equations of Quincke and Worthington, and Ferguson's empirical formula increase in accuracy with increasing size of drop, since the first term of each contains Quincke's assumptions. It can be assumed, on the other hand, that the drop is infinitesimally small and as a result takes on the shape of a segment of a sphere as shown in Fig. 5. The deviation from this shape will be that due to flattening of gravity which is a consequence of taking a drop of finite size.

Dorsey[32] gives the following equation:

$$a^2 = r^2(0.05200/f - 0.12268 + 0.0481f) \qquad (28)$$

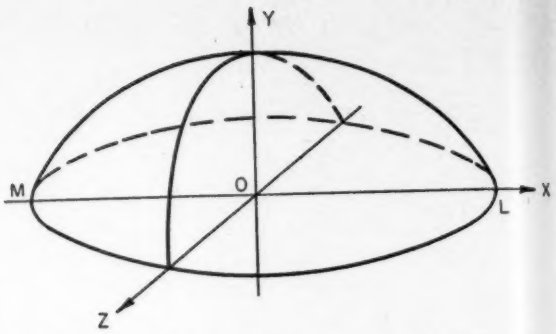


Fig. 4. The sessile drop, with a contact angle of less than 90°, showing distances, LOM, which is contained in Ferguson's formula.

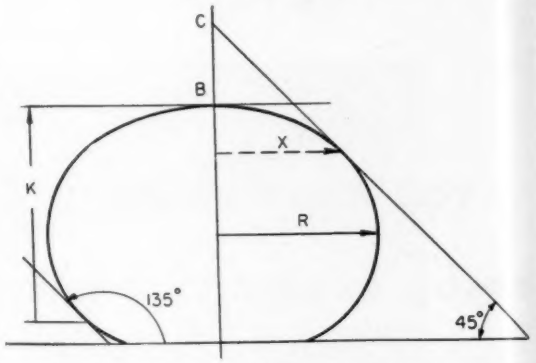


Fig. 5. The sessile drop. Necessary symbols for Dorsey's formula are shown.

where: $a^2 = \gamma/g\rho$

$f = (x_{135} - k_{135})/r$

f may be regarded as a measure of the flatness of the drop, and equals unity for a segment of a perfect sphere.

Dorsey also gives a table which is based on the above formula but includes a correction for different values of r/a. This may be used for larger drops than equation (28) above.

(*To Be Continued*)

LECTURES FROM EUROPEAN CHEMICAL ENGINEERING CONFERENCE TO BE PUBLISHED

Twenty-three lectures by lecturers from ten different countries were delivered at the recent European Convention of Chemical Engineering, which was held at Frankfurt, Germany, in conjunction with the twenty-fifth Congres International de Chimie Industrielle and the Achema X.

The lectures deal with the following main themes: Basic Chemical Engineering, Automatic Measuring and Control Devices in the Laboratory and Works, Continuous Chemical Processes, The Realization of Extreme Conditions in Chemical Engineering, and Materials and Corrosion. The volume will comprise about 500 pages, with 225 illustrations. The price to members of the Dechma is DM 30 per volume; to non-members, DM 37.50 per volume. Orders should be sent to Dechema, Deutsche Gesellschaft fur chemisches Apparatewesen, Frankfurt am Main 13, Postfach, Germany.

BATTELLE TO ERECT NEW LABORATORY

Battelle Institute broke ground recently for a new million-dollar "special purpose" laboratory building. Construction was authorized by the National Production Authority because of the important defense research being conducted at Battelle.

Some 300 industrial firms, in addition to the Air Force, Army, Navy and Atomic Energy Commission, are sponsoring important research studies at Battelle. Director Clyde Williams estimates that in the space provided by the new building, Battelle will be in a position to conduct an additional $2,000,000 worth of research for defense agencies and defense industry.

• A national award to Libbey-Owens-Ford Glass Company for an advertising campaign to broaden markets, made by the National Industrial Advertising Association, was presented in Chicago to Franklyn R. Hawkins, Advertising Manager of the firm.

These glassmakers Tested and Standardized on

B&W ALLMUL FIREBRICK

"We conducted year-long, side-by-side tests of Allmul and a semi-mullite brick in the walls, floors and arches of four hot ports. B&W Allmul proved so satisfactory that we've specified it as 'standard'... ordered five carloads."

"After a year in port necks and uptakes, B&W Allmul's appearance was far superior to that of semi-mullite refractories. We are re-ordering Allmul in carload quantities."

"How good is Allmul for burner blocks in hot ports? Our checks showed it gives four to seven times longer life than the firebrick previously used. We've ordered fifty Allmul burner blocks to date."

Why not test B&W Allmul Firebrick for yourself? You, too, may profit from Allmul's extra-long service life which gives you longer campaigns. Most important, this durable, electric-fused mullite firebrick offers a remarkable economic advantage: it costs approximately as much as semi-mullite brick . . . yet equals the performance of other electric-fused mullite refractories costing substantially more.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42ND ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA

R-488

B&W REFRACTORIES PRODUCTS—B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick B&W Refractory Castables, Plastics and Mortars • OTHER B&W PRODUCTS—Stationary & Marine Boilers and Component Equipment . . . Chemical Recovery Units . . . Seamless & Welded Tubes . . . Pulverizers . . . Fuel Burning Equipment . . . Pressure Vessels . . . Alloy Castings

RESEARCH DIGEST . . .

(*Continued from page* 472)

brightness. In commercially good conditions, 4/10 to 5/10 oz. of cobalt per ton of glass from batch is sufficient.

To get consistent results with the minimum consumption of selenium, the furnace combustion must be well controlled to give nearly neutral conditions. In particular, strong reducing conditions must be avoided as they may have a serious effect on the color.

Ideally, the load on a furnace should be kept as steady as possible at a rate near to the maximum capacity of the furnace. Too high or too low temperatures may cause an increase in the consumption of selenium.

The pink color due to selenium strikes in the temperature range at and immediately above the annealing temperature. Thick-walled ware will remain in this temperature range longer than thin-walled ware and thus different results can be obtained from one furnace. Conservation of the sensible heat in the glass containers between the forming machine and the hot chamber of the lehr is beneficial and may lead to an economy in selenium.

Summing up, the following steps will lead to economy in the use of selenium and will help to produce good "white flint" glass: (1) use good quality batch materials; (2) use clean cullet in controlled amounts; (3) insist on good housekeeping to eliminate avoidable contamination; (4) melt at a steady rate, preferably just under the maximum melting rate for the particular furnace; (5) control combustion conditions in the furnace; (6) avoid excess arsenic; (7) use a little niter, but avoid excess; (8) avoid excess sulphate; (9) avoid excess cobalt oxide; (10) conserve the sensible heat in the container until it reaches the hot part of the lehr.

MINNEAPOLIS-HONEYWELL NAMES DIVISION SALES MANAGER

The appointment of C. L. Peterson as General Sales Manager of the Industrial Division of Minneapolis-Honeywell Regulator Company has been announced by L. Morton Morley, Vice President of the division.

Mr. Peterson has been regional manager for the company's midwest region in Chicago since 1950 and succeeds W. H. Steinkamp.

An engineering graduate of the University of California, Mr. Peterson joined the company in 1927 as sales engineer in the San Francisco office. In 1945 he was appointed regional manager for the parent company's Pacific region.

DIAMOND ALKALI TRANSFERS EXPORT SALES ACTIVITIES

Diamond Alkali Company has announced that the export sales activities of its subsidiary, Kolker Chemical Works, Inc., have been transferred to Diamond's Export Sales Division in New York. Kolker, which was acquired by Diamond in August 1951, specializes in organic chemicals for agriculture and industry.

S. B. Honour, who handled export sales for Kolker, will continue in that capacity for Diamond, assisting S. S. Savage, Director of export sales.

• DESIGN
• ERECTION
• OPERATION

of Glass Plants

DOMESTIC AND FOREIGN

Complete Glass Plants and Equipment, Batch Systems, Glass Melting & Sodium-Silicate Furnaces, Batch Feeders, "Schmid" Mechanical Gob Feeders, "Liberty" Pneumatic Gob Feeders, Automatic Handling Equipment, Stackers, Lehrs, Machines, etc. for manufacture of containers, flat glass, pressed ware, and tubing. Furnace Repairs and Rebuilding. Process Engineers.

ARTHUR W. SCHMID COMPANY

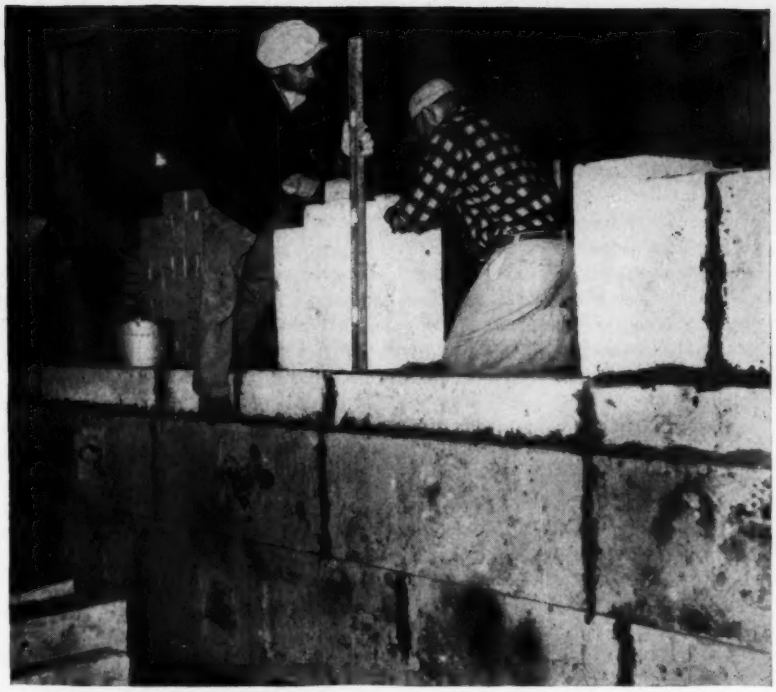
ENGINEERS AND CONTRACTORS

INVESTMENT BUILDING, PITTSBURGH, PA.

Cable address: "Schmid" Pittsburgh
"Glasprint" New York

International Division: 444 Fourth Avenue
New York 16, N. Y.

another well balanced tank takes shape



This is a side port container glass tank which is gas fired. It's used for melting milk bottle glass and for flint container glass.

THIS TANK USES "MONOFRAX" H
tucks
port bottoms
port jambs
breast walls
bridge wall covers
doghouse mantle
and doghouse arch

"MONOFRAX" MH
throat
sump
side walls
(complete, two-course)
bridgewall
back wall
and doghouse

Every month a growing number of tanks are being made like this one — with a balanced combination of MONOFRAX fused cast refractories. As panel tests are completed, results clearly show these high alumina refractories outwear and outperform any other refractory per dollar invested. This refractory team is job-designed to meet the varied operating conditions existing in different parts of different tanks. Something that no *one* heavy duty refractory can possibly do.

MONOFRAX H material, for example, is ideal for *superstructure* service. Containing over 99% beta alumina it is extremely resistant to high temperatures, heat shock, and chemical reactions. It's very durable, not prone to spall off into the bath.

Type MH is a tank proper material containing over 98% alpha and beta alumina. This combination results in a dense material that is highly resistant to erosion. It's also the purest available refractory (its impurities total less than 0.07%).

Type K is the most joint-erosion resistant material currently available. It's particularly valuable where upward drilling is a problem.

For actual proof, test these materials in your own tanks and superstructures and against all types of glass. The evidence will speak for itself. For further information address: Dept. L-92, Refractories Div., The Carborundum Co., Perth Amboy, N. J.

Fused cast refractories by

CARBORUNDUM

Trade Mark

for long campaigns . . . quality glass

"Carborundum" and "Monofrax" are registered trademarks which indicate manufacture by The Carborundum Company.

STANDARDS OF TEMPERATURE . . .

(*Continued from page* 468)

point is very close to 0.0100°C. (0.00997°C.) and that its value as obtained with the triple-point cell is reproducible to within approximately 0.0001 degree C.

Next in importance to the ice point (or triple point) is the steam point, defined as the temperature of equilibrium between liquid water and its vapor under the standard pressure of 1,013,250 dynes per square centimeter (one atmosphere). The Bureau has conducted considerable research in an effort to make this temperature as reproducible as possible. While the steam point may be determined in a boiling-point apparatus left open to the atmosphere, corrections for atmospheric pressure, which is constantly changing, must be made; and precision is difficult to obtain in this way. The Bureau has therefore developed a controlled pressure system, employing a precision manometer, which has been used for the calibration of standard platinum resistance thermometers. A closed boiler, into which six thermometer wells extend, is connected to the precision manometer by a tube filled with helium. The manometer, located in a temperature-controlled pit, consists of a mercury column with a mercury cell at each end mounted on Hoke gage blocks.

Adjusting the difference in the heights of the two columns of gage blocks establishes the desired pressure, which is transmitted by means of the helium to the closed boiler. In order to determine the heights of the mercury surfaces in the mercury cells, the electrostatic capacity between the mercury surfaces and insulated metal plates above them is made a part of a beat-frequency oscillator circuit. After the manometer is adjusted, a change in pressure is detected by a change in the beat frequency. The pressure can be returned to its original value by the manual adjustment of a small piston in the helium system. With this equipment, a change in pressure equivalent to 0.00001 degree C. at the steam point can be detected, and determinations of the steam point made during one day agree within 0.0001 degree C.

Until recently, standard platinum resistance thermometers were calibrated singly at the sulfur point using apparatus open to atmospheric pressure. However, as a result of NBS research, the use of pressure control has now been extended to measurements of the sulfur point. Previously, variations in atmospheric pressure had been both troublesome and a source of uncertainty in the measurements, and most of the determinations were being made at night because pressure variations are smaller during that period. The new method uses a closed aluminum boiler having wells for 10 thermometers and connected to the precision manometer. This apparatus will make possible a study of the sulfur point as a precise fixed point for thermometry.

The Bureau is now working to obtain the closest possible agreement between the thermodynamic and the International Temperature Scale. To aid in this work, a "noise thermometer" developed at the University of Chicago[6] has been set up at NBS to measure thermodynamic temperatures. The mean-square voltage due to thermal fluctuations in electron density in a resistor—usually referred to as thermal noise—is a function of the thermodynamic temperature of the resistor. By comparing the noise voltage across two resistors at different temperatures, it is possible to determine ratio of the temperatures of the resistors. The first measurements will be made of the temperature of the gold point, which is important both for the thermocouple and optical-pyrometer ranges of the International Temperature Scale.

Closely related to the work on the temperature scale is the development of improved temperature-measuring instruments. Thus, in connection with the maintenance and improvement of the International Temperature Scale in the temperature range from 630.5° to 1,063°C., investigations[7] have been made to determine the effect of annealing on the electromotive force of standard platinum versus platinum-rhodium thermocouples. This study included a determination of the effects of different annealing temperatures, cooling rates and atmosphere in which the thermocouples were cooled. It was found that some of the electrical properties depend upon the rate of cooling and that not only chemical purity but also mechanical strains must be controlled for maximum uniformity.

A search is now under way for a better material to substitute for the alumel wire of a chromel-alumel thermocouple. When used under conditions encountered in exhaust gases in aircraft engines, the alumel becomes brittle and fails after a relatively short period of operation. Available substitutes for alumel which appear likely to withstand the vibration and corrosive atmosphere are being investigated to determine their performance under these extreme conditions.

Future plans call for the construction of comparator furnaces to study the performance of standard platinum resistance thermometers and thermocouples between calibration points. As the International Temperature Scale is based on a relatively small number of fixed points, it is necessary to investigate the standard temperature-measuring instruments between these points and to evaluate the precision with which they can be used over the intervening ranges. In this way the Bureau hopes to ensure that standard calibrated instruments of a given type indicate the same temperature at any temperature within their range.

Investigative work is also carried on in connection with the testing of clinical thermometers. Recently, in order to develop an improved specification for clinical thermometers, a study[8] was made of the change with time in the calibration of a group of thermometers which had been given a special stabilizing heat treatment by the manufacturer. Previous specifications had required that clinical thermometers be aged by three months' storage before calibration so that the volumes of the bulbs would have time to become constant. The result of the Bureau's study showed that the "artificial aging," which requires less than a week, is fully equivalent to the earlier method.

A significant advance in the measurement of extremely high temperatures was the recent development of an iridium—iridium-rhodium thermocouple. Because of the high temperatures—up to about 3800°F.—which prevail in the primary burning zones of turbojet and ramjet combustion chambers, conventional temperature-sensing instruments are not suitable for use in these applications. In preliminary studies, the new thermocouple has been found to withstand both the thermal and mechanical stresses incident to combustion-chamber operation, and heat-resistant supporting tubes and insulators are now being developed so that the device can be used in flight.

At very low temperatures (below 50°K.) NBS research on thermometry has two major objectives: first, the determination of thermodynamic temperatures by means of a gas thermometer and, second, the development of convenient, sensitive and reproducible secondary thermometers which can be calibrated by means of the gas thermometer. Since the development of a highly accurate gas thermometer for this purpose requires painstaking and time-consuming precision, the work on the secondary thermometer is being pursued concurrently. Resistance thermometers constructed of the semiconducting elements, silicon and germanium, have proved to be extremely sensitive; in some cases the resistance changes more than 50 per cent per degree. While satisfactory reproducibility still remains a problem, results of initial tests have been quite promising.

REFERENCES

[1]New International Temperature Scale, NBS *Technical News Bulletin 33*, 28 (March 1949).

[2]The International Temperature Scale of 1948, by H. F. Stimson, *J. Research* NBS *42*, 211 (1949) RP 1962.

[3]Differences between the International Temperature Scales of 1948 and 1927, by Robert J. Corruccini, *J. Research* NBS *43*, 133 (1949) RP 2014.

[4]The measurement of some thermal properties of water, by H. F. Stimson, *J. Washington Acad. Sci. 35*, 201 (1945).

[5]NBS *Technical News Bulletin*, No. 305, 71 (1942).

[6]Absolute noise thermometer for high temperatures and high pressures, by J. B. Garrison and A. W. Lawson, *Rev. Sci. Inst.* 20, 785 (1949).

[7]Annealing of platinum for thermometry, by R. J. Corruccini, *J. Research* NBS *47*, 94 (August 1951), RP 2232.

[8]Aging changes in clinical thermometers by Lawrence C. Liberatore and Raymond E. Wilson, *J. Am. Ceramic Soc.* (in press).

• Ansul Chemical Company has announced the appointment of Paul R. Larimer as General Sales Manager in charge of all four sales divisions—fire extinguisher, refrigeration, industrial chemicals and export.

GLASS FIBERS ELECTS EXECUTIVE VICE PRESIDENT

Thomas A. Collins has been elected to the newly-created position of Executive Vice President of Glass Fibers Inc., at a recent meeting of the company's Board of Directors. This announcement was made by President Randolph H. Barnard.

Mr. Collins has spent his entire business career in the glass and glass fiber industry. He began with Owens-Illinois in 1926 as supervisor of mold manufacturing. From 1932 to 1934 he was with the engineering department of the Industrial Materials Division, forerunner of Owens-Corning Fiberglas Corporation; then, progressively was manager of the Gas City, Indiana plant; Western glass container factories manager; general factories manager of the Libbey Division and then Kaylo Division of Owens-Illinois. He recently resigned as General Manager of the Kaylo Division.

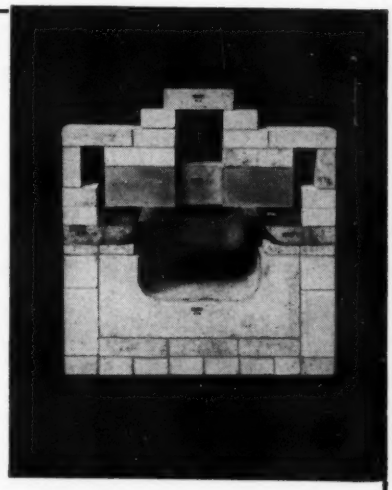
Mr. Collins will headquarter at Glass Fibers' home office in Toledo and detail of duties will be announced at a later date, Mr. Barnard said.

PEMCO ADDS STUDENT TRAINEES

The experience of five different universities lies behind the new ceramic engineers at Pemco Corporation.

Henry J. Baker comes from Penn State. From Alfred University are Edward L. Decker, Herbert W. Larisch and John M. Morgan. Frank R. Kalman is a graduate of Ohio State. George S. Huber, after acquiring his degree in ceramics at Rutgers, went on to achieve a master's degree in Harvard's Business School.

Cleaner Glass, Low Maintenance with **CRYSTALITE Forehearths**



REMMEY CRYSTALITE (mullite-bonded mullite) is produced in all shapes necessary to make up the forehearth assembly. Burner blocks, cover blocks, channels, spouts, tubes, plungers and orifice rings are built to meet specified requirements. These CRYSTALITE parts mean better, more efficient production by offering:

★ Accuracy in formation to eliminate time-wasting adjustments.
★ High refractoriness and erosion resistance for longer life, fewer replacement shutdowns and cleaner glass.
★ Rigid control through each production phase for uniform quality and dimension accuracy.

Get Premium Performance Without Premium Price . . . by using REMMEY CRYSTALITE parts for your forehearth.

Dependable Refractories

REMMEY

RICHARD C. REMMEY SON CO.
Philadelphia 37 • Pennsylvania

A battery of special electric ovens for annealing of light ware for the electronics division of a prominent manufacturer. These ovens are now employed in three plants.

Whatever your problem in the Glass Industry—our organization can design, engineer and construct the equipment and plants to meet your every requirement.

Superior equipment is our practice — Service is our creed.

HENRY F. TEICHMANN, INC.

INVESTMENT BUILDING PITTSBURGH 22, PA.
Telephone: COurt 1-6210 *Cable:* HEFTINC

1952 INTERNATIONAL GLASS COMMISSION MEETINGS IN ENGLAND

The International Commission on Glass held its annual meetings in three different cities—The Institute of Physics, London, The Glass Works and Research Laboratories of the General Electric Ltd., Wembley, and the Department of Glass Technology, University of Sheffield—during the week of June 30-July 5.

Representatives from Belgium, France, Germany, Great Britain, Holland, Japan, Spain, Sweden, Switzerland and the USA attended the sessions. Dr. N. J. Kreidl, American representative and official representative of The American Ceramic Society, served as one of the discussion leaders in the symposium "Iron in Glass" held during the Open Joint Session. Mr. V. Young attended as United States delegate.

The technical work of the Commission occupied three full days, one of them devoted to an Open Session. The other two days were devoted to Committee work on a variety of subjects classified under the group headings of Glass Literature; The Chemical Properties of Glasses; The Physical Properties of Glasses, and Glass Furnace Problems.

At the Open Joint Session of the International Commission on Glass and the British Society of Glass Technology on July 4, the fifth day of the meeting, many technical advances were divulged.

In the symposium on "Iron in Glass," speaker Dr. J. M. Stevels, Holland, proposed three semiquantitative parameters to better describe glasses containing iron. They were: a (the constitutional factor giving the ratio of glass forming over all constituents in a novel manner),

1 and only one—company can supply the *full line* of glasshouse lime and limestone products. Gold Bond High Calcium and Dolomitic Limestone...Gold Bond Dolomite Fluxing Lime and Hydrates... Gold Bond Low-Iron Calcium Carbonate... also pottery and casting plasters.

Ceramics Division

Gold Bond INDUSTRIAL PRODUCTS

NATIONAL GYPSUM COMPANY
BUFFALO 2, NEW YORK

Use **Pennsalt Aqueous Hydrofluoric Acid**

for etching and polishing glass

Available in 60% and 70% commercial grades
Packed in 165, 450 and 900 pound steel drums
Shipped from:
Cornwells Heights, Pa.
Natrona, Pa.
Calvert City, Kentucky

Save time by calling the nearest Pennsalt District Office

DISTRICT OFFICES AND TELEPHONES
Philadelphia 7, Pa.
Locust 4-4700
Appleton, Wis.—Appleton 3-9307
Berkeley 4, Calif.—Ashberry 3-2537
Chicago 1, Ill.—Andover 3-6170
Cincinnati 2, Ohio—Main 3168
Detroit 26, Mich.—Woodward 1-8051
Los Angeles 11, Calif.—Jefferson 6244
Paterson 1, N. J.—Lambert 5-3500
Pittsburgh 19, Pa.—Atlantic 1-5233
Portland, Ore.—Atwater 7655
Tacoma 1, Wash.—Main 9101

Pennsylvania Salt Manufacturing Company
1000 Widener Building, Philadelphia 7, Pa.

Pennsalt Chemicals

β (the reduction oxidation factor giving an electron count attached to iron), and γ (the energy exchange factor accounting for the ease of energy transfer through the oxygen array).

In the paper "Calculation of Coal Consumption on the Basis of the Furnace Performance Formula," England's C. E. Gould presented, in absentia, a further sequence of his classical study of tank furnaces.

R. W. Douglas, England, supported by other British General Electric research people, brought out novel experiences in expansion behavior, including his spectacular experiment on the isothermal relaxation of a mechanically stressed cut-open silica ring.

Other papers given were: "A Re-examination of the Adams-Williams Law of Annealing" by Dr. F. W. Preston, United States; "Fracture Processes in Glass" by Dr. H. Schardin, Germany; and "Crucibles Used in Ancient Egyptian Glass Melting Operation 1400 BC" by Dr. W. E. S. Turner, England.

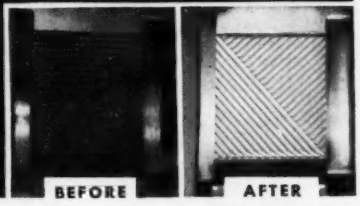
PENNSALT INCREASES CHLORINE TRIFLUORIDE CAPACITY

An increase in the availability of liquid chlorine trifluoride is announced by the Pennsylvania Salt Manufacturing Company with the completion of new manufacturing facilities at the company's plant in Natrona, Pa. The product has been manufactured in experimental quantities for the past six years at the company's Whitemarsh Research Laboratories, and the new installation has been constructed to meet the increased demand for chlorine trifluoride.

POLARISCOPES
for
Qualitative Observation
•
POLARIMETERS
for
Quantitative Measurement
•
POLARIZING INSTRUMENT CO., Inc.
273 N. Bedford Road
Mt. Kisco, N. Y.

AMCO
Design, Erection and Operation of Manufacturing Plants and Furnaces for All Types of GLASS WARE
AMSLER MORTON CORPORATION
CHAMBER OF COMMERCE BUILDING, PITTSBURGH 19, PA.

Hydro-Finish leaves glass molds READY for USE!

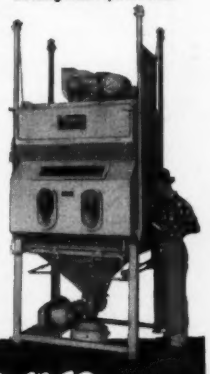


Actual unretouched photos of mold before and after cleaning with Hydro-Finish

Complicated molds are easily cleaned and left *ready for use* with Pangborn Hydro-Finish! Hand cleaning and polishing is virtually eliminated! And you save additional time and labor because a Hydro-Finish machine, operated by one man, removes discoloration and scale in *minutes* instead of hours!

What's more, Hydro-Finish's use of fine-mesh abrasives suspended in liquid gives you a precision job. Sharp edges are maintained . . . tolerances are held to .0001 . . . molds last longer . . . precision equipment is protected.

Get complete facts on Hydro-Finish and how it can save *you* money! Write for Bulletin 1400-A to: PANGBORN CORP., 3400 Pangborn Blvd., Hagerstown, Md.



Pangborn
BLAST CLEANS CHEAPER
with the right equipment for every job

ERSON V. OGG NAMED HOUZE COMPANY OFFICER

Erson V. Ogg, formerly Director of Industrial Relations of the Pittsburgh Plate Glass Company and General Manager of the Phoenix Glass Company, has been named Executive Vice President and General Manager of the L. J. Houze Convex Glass Company, it has been announced by the Board of Directors.

In these capacities, Mr. Ogg becomes the chief executive officer of the company and also has been elected a member of the Board of Directors.

At the same time, the Board announced that C. S. Fray, Vice President-Sales, has been elected a member of the Board of Directors, and that Armand Houze, Sr., son of the founder of the firm, continues as President. Three other members of the Houze family have also been elected to the Board. They are Leon J. Houze, Jr., brother of the president; Armand L. Houze, Jr. and Roger J. Houze, II, sons of the president.

As new chief executive officer, Mr. Ogg succeeds W. H. Board, former Executive Vice President, who with his brother, C. B. Board, retired after more than 30 years with the company. They have offered to serve as consultants to the company during the period of transition.

Prior to his post with Pittsburgh Plate Glass Company, Mr. Ogg was General Manager of Phoenix Glass Company and was more recently associated with Chase Brass and Copper Company as Director of Industrial Engineering.

L-O-F EMPLOYEES GET PAY RAISE

An automatic increase of two cents an hour for production and maintenance employees in plants of Libbey-Owens-Ford Glass Company in Toledo, Charleston, W. Va., Shreveport, La., and Ottawa, Illinois, has become effective.

In accord with the cost-of-living escalator clause in the contract made on May 15 with the Federation of Glass, Ceramic & Silica Sand Workers of America, CIO, all employees covered will get the increase in the first pay period after today. It is determined by the "old" consumers' price index of the Bureau of Labor Statistics which stood at 191.1 as of June 15 compared to the base 100 for the 1935-9 period.

The increase under the escalator provision adds two cents to the 8 cents an hour general wage increase granted as of May 15, but does not apply to any of the other adjustments and differentials provided in the contract.

Correction: In the July 1952 issue of THE GLASS INDUSTRY in the Inventions and Inventors Department, Page 365, Patent No. 2,597,272 was incorrectly reported. This should have been Patent No. 2,597,373.

GLASS SPECIALTIES

Transparent Colored Blown Sheet Glass
Solid Pot Opal Blown Sheet Glass
Flashed Opal Blown Sheet Glass
Colonial Antique Colored Glass
Heat-Ray Resisting (Cool Glass)
"TWIN-RAY" — the scientific illuminating glass.

HOUZEX

L. J. HOUZE CONVEX GLASS CO.
POINT MARION, PENNSYLVANIA
New York Office: 110 West 40th Street
Chicago Office: 1597 Merchandise Mart
"IF IT'S MADE OF GLASS, ASK US FIRST"

ENGINEERS
To The Glass Industry

Container Plants • Tableware Plants
Bulb and Tube Plants • Flat Glass Plants
Batch Systems • Fuel Systems
Furnaces • Lehrs • Feeders
and other special production equipment.

FORTER-TEICHMANN Company
Clark Building, Pittsburgh, Pa.
Cable "Forter" Phone EXpress 1-0820
Incorporated 1936

PRECISION GLASS CUTTING
for the
LAMP AND ELECTRONIC TUBE INDUSTRIES

The Engineering Glass Laboratory Inc. is completely equipped for cutting all types of glass tubing to very close tolerance specifications.

Our many years of experience and "know how" in servicing many of the leading companies is your assurance of receiving top quality workmanship.

Our Engineers will be glad to consult with you on any of your glass cutting problems.

ENGINEERING GLASS LABORATORY, INC.
418 Central Ave., Newark 7, N. J. MArket 3-2113

EISLER
Automatic Glass Machinery
For the Manufacture
of Incandescent Lamps and All Types of Electronic Tubes

BULB BLOWING MACHINES—AMPULE MACHINES
FORMS ALL TYPES AND SHAPES OF BULBS MADE FROM GLASS TUBING
VACUUM PUMPS, GLASS SLICING MACHINES
TORCHES—BURNERS

DIFFERENT TYPES AND SHAPES MADE ON EISLER'S AUTOMATIC AMPULE MAKING MACHINES

WE INVITE YOUR INQUIRIES

EISLER ENGINEERING CO., INC.
742 SOUTH 13TH STREET (near Avon Ave.) NEWARK 3, N. J., U.S.A.

CLASSIFIED ADVERTISEMENTS

WANTED

Need for production: Simpson Mixer, Raymond Mill, one or two Vibrating Screens. Please give full particulars. P. O. Box 1351, Church Street Station, New York 8, New York.

HELP WANTED

GLASSMAKING ENGINEER, for optical, colored and Fourcault sheet manufacturing. Management opportunity if qualified. Penberthy Instrument Company, 666 Adams, Seattle, Washington.

SUPERINTENDENT to manage decorating department of a glass container manufacturing plant located in the southwest. Give qualifications and salary expected. Reply to Box 121, c/o The Glass Industry, 55 West 42nd Street, New York 18, N.Y.

CHEMICAL ENGINEER EXPERIENCED BOTTLE MANUFACTURING

To act as Manager modern bottle making plant in South America. Three years experience required. House, all expenses, plus appropriate salary. Good financial opportunity. Write full details to Western Metals and Trading Co., Inc., 30 Pine Street, New York 5, New York.

• Secretary of Commerce Charles Sawyer has named Faustin J. Solon, Vice President of Owens-Illinois Glass Company, to serve on the National Distribution Council.

PITTSBURGH CORNING APPOINTS INSULATION SALES MANAGER

The appointment of C. P. Barrett as Manager, Industrial Insulation Sales, for the Pittsburgh Corning Corporation, has been announced by Paul D. Japp, General Sales Manager.

Mr. Barrett has been connected with Pittsburgh Corning in all phases of the company's industrial insulation sales activities, since 1947. He has served as a field representative in New York City and Chicago as District Manager of the company's Chicago office and as Eastern Manager, Industrial Insulation Sales, in New York City.

AMERICAN POTASH APPOINTS BOARD MEMBER

Appointment of D. S. Dinsmoor, Vice President in charge of research and development, to the Board of Directors of American Potash & Chemical Corporation has been announced by Peter Colefax, President.

Mr. Dinsmoor, who joined the company in 1948, formerly was Vice President of the Monsanto Chemical Company and served as General Manager of the Merrimac Division at Everett, Mass.

DELOS M. PALMER & ASSOCIATES

Consulting Engineers

Reg. Mechanical, Electrical & Industrial

•

Designers of Special Purpose
Glass Forming, Decorating and
Handling Machines

•

4401 JACKMAN ROAD **TOLEDO 12, OHIO**

Telephone: Kingswood 9611

THE SHARP-SCHURTZ COMPANY

CHEMISTS AND CONSULTING
ENGINEERS
FOR THE GLASS INDUSTRY

LANCASTER, OHIO U. S. A.

***WISSCO* STEEL PROCESSING BELTS**

FOR EFFICIENT ANNEALING OF GLASS AND CERAMICS

- The right alloy steel
- Heavy load capacity
- High resistance to heat, abrasion and corrosion
- Complete heat circulation
- Limited surface contact
- Proved operating economy

Try Us On Your Next Order
Write to 56 Sterling Street Clinton, Massachusetts

WISSCO BELTS

PRODUCT OF WILKINSON SPENCER STEEL DIVISION
THE WARREN FUEL & IRON CORPORATION

NATIONAL AIROIL are *SPECIALISTS* in COMBUSTION EFFICIENCY

Detailed information gladly sent upon request

- Steam Atomizing Oil Burners
- Mechanical Atomizing Oil Burners
- Low Air Pressure Oil Burners
- Rotary Oil Burners
- Industrial Gas Burners
- Combination Gas and Oil Burners
- Tandem Block Combustion Units
- Fuel Oil Pump Sets
- Refractory Burner and Muffle Blocks
- Valves, Strainers, Furnace Windows

NATIONAL AIROIL BURNER CO., INC.

1255 East Sedgley Avenue, Philadelphia 34, Pa.
Southwestern Div.: 2512 So. Blvd., Houston 6, Tex.